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ERRATA

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Page 266, line 25: for "Wilbur" read "Orville."
Page 360, line 21: for "Tephrosia carpinteria" read "Tephrosia carpenteria."
Page 360, line 22: for "*Cracca carpinteria*" read "*Cracca carpenteria.*"
Page 475, line 8: for "assistant chemist" read "associate biochemist."

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PHYSICS.—*Adsorption and pycnometry.*[1] P. G. Nutting, U. S. Geological Survey.

It is well known that adsorbed films may profoundly affect the apparent density, permeability and other physical properties of very finely divided solids. Adsorbed water chokes the pores of clays and obstructs the percolation of water through them. Bleach clays bleach by means of their selective adsorption of the various constituents of the fluids in contact with them. That adsorption is of several kinds and many degrees is shown by the diversity of weight-temperature relations. It seemed worth while to investigate the possibilities of pycnometry in resolving this group of problems, using a number of conditioning temperatures and pycnometric fluids in the study of some highly adsorbing clays. Since the density changes are slight, the utmost precision is necessary.

Weighings to one part in ten thousand offer no difficulty. The volume of any good pycnometer is definable with nearly as great precision, and most of the other errors are controllable with careful work. The chief difficulty lies within the sample itself; in interpretation of its moisture content, the expulsion and solution of air and moisture by the pycnometer fluid and the adsorption of pycnometer fluid on grain surfaces.

Definite volumes are best secured and evaporation is minimized with pycnometers that use an optically flat cover, such as the bottle form of Johnston and Adams[2] or the flat dish form of the writer.[3] The latter form has the added advantage that it is also useful for determining lump densities. Fair results may be obtained with an ordinary form of pycnometer having a ground-in stopper if it is well constructed. Walls too thin to withstand wiping pressures, poorly ground-in stoppers and grooves between stopper and neck are common defects.

[1] Published by permission of the Director, U. S. Geological Survey. Received December 11, 1935.

[2] Jour. Am. Chem. Soc. **34**: 566. 1912.

[3] Bull. Am. Assoc. Pet. Geologists **14**: 1344. 1930.

Errors due to temperature changes during manipulation cannot be obviated entirely but may be made negligible if direct contact between pycnometer and the fingers is avoided and if the work is done in a room with temperature constant for several hours to within a few tenths of a degree. Pycnometers with built-in thermometers and bath thermostats for bringing the pycnometer to a fixed temperature introduce more errors and uncertainties than they eliminate, in the writer's opinion. The method preferred by him is to choose a time of day for making weighings when the room temperature has changed very little for several hours and is changing at a rate less than one-fifth degree per hour. The pycnometer volume is freshly determined (with water) just before and just after each determination of grain volume and of density of pycnometer fluid.

The pycnometer fluid. The prime essential of a pycnometer fluid is its wetting power—its ability to expel air. Further it should not dissociate or polymerize during use, nor should it combine with or be adsorbed on the surface of the material under test. No one fluid can be used on all materials and only a few are entirely satisfactory for any material. Water is fairly suitable for finding the volume of a paraffin-coated lump but it is one of the worst possible choices for such granular materials as clays and soils, as it tends to be adsorbed, and to emulsify air instead of completely expelling it. Some minerals appear to take up hydroxyl and hydrogen unequally, thus decomposing water.

The aromatics and chlorinated compounds, which are least adsorbed and "cracked" by clays and soils, appear to have the widest range of application as pycnometer fluids. Highly refined and stabilized paraffines, such as the laxative mineral oils, are cracked by many active clays, but the chlorinated compounds are not. Dichloroethyl ether ("chlorex"), tetrachloroethane and the mono-, di- and trichlorobenzenes are quite satisfactory in this respect. The writer's favorite pycnometer fluid for years has been tetrahydronaphthalene ("tetralin"). This and the chlorinated compounds just mentioned are but slightly adsorbed on soil grains, they are powerful wetting agents, they decompose or polymerize very little in use and they disturb existing hydrates very slightly if at all. They have low vapor pressures, moderate densities, and moderate thermal expansions.

Preparation of sample. The first step is to define the substance whose mean density it is desired to measure. Practically every sample contains adsorbed air and moisture, both of which reach significant proportions when the specific surface is large. Soil and clay samples

may contain organic matter, oil sands contain oil and tarry adsorbed films, textile fibers have gummy coatings. A proper pycnometer fluid will remove the air. Moisture may be removed by room drying, desiccation, oven drying, or ignition, as the case may be. Free oil may be removed by washing, adsorbed oil and organic matter only by ignition or by "wet combustion" with chromic acid. When grain and lump densities are to be determined to find porosity, obviously the same contaminations must be removed for both determinations.

Incomplete air removal of course means a first order error in density determinations. Even with a powerful wetting fluid all the air cannot be expelled from a clay in a reasonable time without fairly fine grinding. Grinding to a powder to pass a 300 mesh screen may increase errors due to adsorption because the specific surface is thereby increased. Experimental evidence indicates that interstitial air is expelled in an hour or less, whereas trapped internal air diffuses out of 0.1 mm. grains and escapes only after several hours. For the most precise work on the finest grained clays, the 150 mesh material (sieve openings 0.1 mm.) is weighed and wet down with tetralin or chlorex, then left over night before the final stirring, filling, and weighing. Density determinations that are repeatable to a few parts in ten thousand may be obtained by this method.

Another first order factor is the proportion of water in the sample. If attention is to be centered on the density of the grains free from any given variety of water (such as absorbed, adsorbed, or osmotic water), such water should be removed previous to the density determination. If this is not done the density found will obviously be merely that of the complex involved, including the water. The nature of the water will usually have to be determined by special tests, if such determination is possible. It is well known that substances that form hydrates tend to lose their water abruptly at some definite temperature or vapor pressure, whereas substances like clays and soils lose it continuously up to the point at which essential water is lost. Owing to lack of further criteria the non-essential water in these substances is generally considered to be adsorbed water. The writer feels that density determinations even on materials containing more or less adsorbed water may throw some light on the phenomena of adsorption, and this in turn on the true density of the mineral grains. Weight-humidity and weight-temperature relations for a number of clays are given in one of the author's papers.[4]

As an illustration of density differences due to the condition of the

[4] U. S. Geol. Survey Circular **3**: 24–38. 1933.

sample, a +150 mesh fraction of a local soil showed a mean grain density of 2.428 when in equilibrium with room air at 27°C. and 20 per cent humidity and 2.650 after drying at 160°C. The ignited material had a density of 2.405. The room-dry density includes considerable adsorbed water while the low density after ignition probably represents material that has lost its organized structure and that may be even slightly sintered together. Conditioning of the sample at 160°C. for at least two hours is standard practice with the writer. This expels all loosely held moisture without breaking down the more stable hydrates or carbonates. For material that contains considerable cellulose or other organic matter, probably 140°C. would be better. For shales, 200°C. is preferred.

Adsorption of pycnometer fluid on grain surfaces introduces a second-order error in density determinations by making the apparent volume too small and the density too great, because the adsorbed layer is condensed to above-normal density. As this adsorptive force decreases rapidly with distance from the adsorbing surface, it is not practicable to correct for it.

Water or other matter that is adsorbed on mineral grains must obviously yield a density for the material as a whole that will be lower than that of grains with no adsorbed matter. Part or perhaps all of this adsorbed moisture may be removed by heating. An experiment with quartz may illustrate the point. A piece of crystal free from inclusions was crushed to about 3 mm. and a portion of this further crushed to just pass a 300 mesh sieve. The coarse lumps and the fines, after ignition, gave the densities 2.6440 and 2.6438 gm/cc., respectively (in water). Before ignition, however, the fines exposed over night to room conditions (temperature 25° and humidity 52 per cent), gave 2.6342. A weight-temperature curve run on the raw fines showed 1.0061 at 25°, 1.0049 at 100°, 1.0034 at 200°, and 1.0018 at 400°, relative to base weight at 800°. If 6.1 mg. of water per gram of sample is spread over a specific surface of 400 cm.^{2}/gm. (calculated from size of grains) the adsorbed layer would be 15×10^{-6} cm. or over one hundred molecular layers thick. More direct determinations of this thickness[5] make it 5×10^{-6} cm. (0.05μ) for the inner firmly adsorbed layer.

On glass the adsorption of water is relatively small. Some internal water, however, is expelled by heating to about 500°C. Coarse and fine (300 mesh) pyrex powder showed densities (in water) of 2.2375 and 2.2349 gm/cc. After heating to 480° the fines showed a density

[5] *Adsorptive force of silica for water.* Jour. Phys. Chem. **31**: 531. April, 1927.

of 2.2445 gm/cc. A thermal dehydration curve indicated a loss in weight of 0.3 per cent between 50° and 480° but with a pronounced shoulder on the curve between 160° and 240°C. The internal water removed by heating appears to be restored readily for the density after heating is high.

The effect of thermal conditioning and of pycnometer fluid on density determinations is shown by the following results on typical Florida fuller's earth. The material was from a block of light gray clay that had been room-dried 4 years and freshly ground to 150 mesh. The lump density was 1.0607, voids 52.9 per cent. Grain densities were determined with both water and dichloroethyl ether ("chlorex"), relative weights in a platinum crucible. Room condition was 32°C., 75 per cent relative humidity.

TABLE 1.—DENSITIES OF FULLER'S EARTH

	At room conditions	Dried at 160°C.	Product after heating to 800°C.
Mean grain density in chlorex	2.2513	2.4993	2.6008 gm/cc.
Mean grain density in water	2.2567	2.5903	2.6005 gm/cc.
Difference (Hydration ?)	0.0054	0.0910	0.0003(?) gm/cc.
Observed relative weights	1.2400	1.1511	1.0000
Calculated relative volumes	1.4321	1.1973	1.0000

Ignition at 800°C. rendered the product insensitive to water. Apparently, the preferential adsorption of water, as compared with chlorex, in the pycnometer, added 5.4 mg/cc. to the clay in equilibrium with room conditions, and 91.0 mg/cc. to that conditioned at 160°C. Neglecting a very slight oxidation of iron at 800°, the sample is 24 per cent heavier at room temperature and 15 per cent heavier at 160° than at 800°, because of adsorbed, osmotic, and essential water. The grain volumes are 43.21 per cent greater at room conditions and 19.73 per cent greater at 160° than at 800°. Uncertainties are believed to be at most 3 units in the last place. It should be stated, however, that the figures in the last column are not exactly comparable to those in the second and third columns, as essential water has been driven off at 800° and the material may have been broken down to an indefinite aggregate.

In order to study possible effects of adsorption further, a set of observations similar to the above was made with an imported highly activated acid-treated bentonite, and using gasoline as one pycnometer fluid. This is a finely-ground clay of high bleaching power. The gasoline used had just been liberally treated with bleaching clay

to remove gums, olefines, and other stray constituents. The clay was room-conditioned to 30° and 70 per cent relative humidity.

TABLE 2.—DENSITIES OF HIGHLY ACTIVE CLAY

	At room conditions	Dried at 160°C.	Product after heating to 800°C.
Mean grain density in chlorex	2.2322	2.4218	2.3841 gm/cc.
Mean grain density in water	2.0249	2.4304	2.6504 gm/cc.
Mean grain density in gasoline	2.2242	2.4508	2.3915 gm/cc.
Observed relative weights	1.1623	1.0739	1.0000
Calculated relative volumes	1.2414	1.0571	1.0000

At room conditions this clay held a large amount of water on grain surfaces, but at 160° the greater part of this water had been driven off. The ignited clay had evidently lost practically all of its internal or essential water. Gasoline was adsorbed a little, as compared with chlorex, on the ignited sample but was adsorbed considerably more on that conditioned at 160°. This clay turned a dark brown in a few minutes owing to cracking and to adsorption of cracked portions of the gasoline. An adsorbed layer of gasoline 0.1μ deep on this clay would add about 5 mg. per gram of clay. The decreased density at 800° indicates loss of essential water, and possibly some sintering.

The pycnometer method may be used to study adsorption but it is tedious and troublesome and less satisfactory than direct first-order methods. However, the pycnometer may become a useful tool of research in investigating changes in grain volume on hydration and dehydration, in distinguishing between internal and external water, and in determining pore size in dehydrated crystals.

BOTANY.—*New and noteworthy mosses from Jamaica.*[1] EDWIN B. BARTRAM, Bushkill, Pennsylvania.

The very extensive moss collections made by C. R. Orcutt during his residence in Jamaica during the years 1927–1929 have provided the material for the following list. The record includes only descriptions of the new species, along with pertinent notes on unusual species that are either rare or new to the island.

During his stay in Jamaica Mr. Orcutt sent me parcels of small specimens from time to time, which were determined and reported upon. After his untimely death in Haiti in 1929 his enormous collections were sent to the United States National Museum. The mosses were subsequently segregated and transmitted to me for study. The

[1] Received August 15, 1935.

task of organizing and labelling such a mass of material has proved an onerous one. With the idea of making available the more important information, I have prepared the present paper. The type collections of the new species are in the United States National Herbarium and my own herbarium.

I am grateful to Dr. W. R. Maxon for his help in separating the mosses from the general collection of lower cryptogams with which they were mixed, and also for a nearly complete record of localities and dates which provides data for numerous collections that otherwise would have been of little value.

FISSIDENTACEAE

Fissidens (Aloma) **imbricatus** E. G. Britt. & Bartr., sp. nov. Fig. 1.

Autoica. Caules gregarii vel dense caespitosi, 5–10 mm. alti, contorti, ramosi, densifolii. Folia dense imbricata, rigida, superne anguste lanceolata,

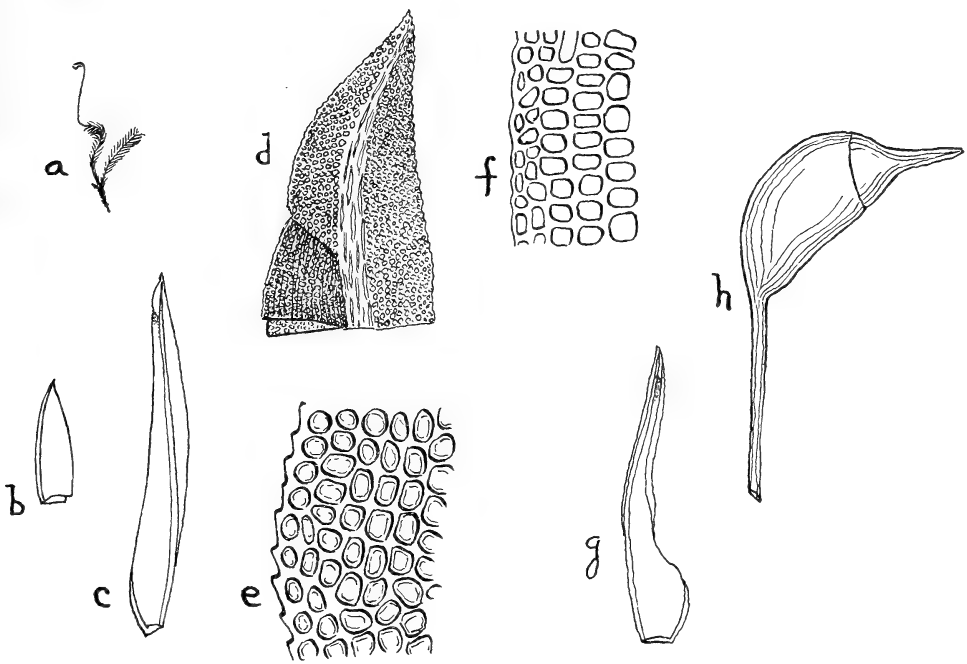

Fig. 1.—*Fissidens imbricatus* E. G. Britt. & Bartr., sp. nov.: *a*, plant ×1; *b*, lower leaf ×22; *c*, upper leaf ×22; *d*, apex of upper leaf ×160; *e*, cells of apical blade and margin ×400; *f*, cells of duplicate blade and margin ×400; *g*, perichaetial leaf ×22; *h*, capsule ×22.

acuta, ad 2 mm. longa; lamina dorsalis angustissima, supra basin enata, inferne minuta; costa subflexuosa, percurrens; margines ubique elimbati, minute crenulati; cellulae superiores hexagonae, circa 10μ, turgidae, parietibus incrassatis, marginales minores, basilares majores, laevissimae, ad 16μ. Seta geniculata, rubra, ad 9 mm. longa; theca inclinata vel arcuata, asym-

metrica, deoperculata circa 0.75 mm. longa; operculum rostratum; peristomii dentes 0.33 mm. longi, fissi; sporae laevissimae, 10–13μ.

TYPE: Schwallenburgh, St. Anne's Parish, Dec. 8, 1927. *C. R. Orcutt* 3942a.

Similar to the rare *F. petrophilus* Sull., but differing in the curled and recurved proliferous stems, longer setae, and inclined or arcuate capsules.

DICRANACEAE

Campylopus Oerstedianus (C.M.) Mitt.

Blue Mountain Peak, nos. 5378 and 5380c.

These collections correspond very well with the description of this species in having the costa merely ribbed on the back and in the poorly developed alar cells. As the ubiquitous *C. introflexus* is a strongly composite species, with innumerable variations, I cannot help feeling somewhat skeptical about the validity of *C. Oerstedianus* as a specific concept.

CALYMPERACEAE

Syrrphodon ligulatus Mont.

Vicinity of Arntully, Nov. 1, 1928, no 6784a. New to Jamaica.

POTTIACEAE

Anoectangium incrassatum Broth.

Vicinity of Arntully, nos. 2779, 3116, 3872, 6755, 6995; Moy Hall, no. 6888; Abbey Green, alt. 5000 ft., on bank; vicinity of Farm Hill, no. 3420. A distinct endemic species which seems to be fairly common, to judge from number of collections.

Hymenostylium glaucum (C.M.) Broth. var. **cylindricum** Bartr. var. nov.

Theca anguste cylindrica, leniter curvata, saepe microstoma, aetate nigrescens.

TYPE: Concrete wall, Farm Hill Works, May 3, 1928, *C. R. Orcutt* 5461.

The cylindric capsules in this variety are noticeably different from the short, ovoid capsules of the typical form. Both are abundantly represented from numerous localities.

Trichostomum sublamprothecium Par.

Moy Hall, no. 6880; vicinity of Arntully, nos. 6791, 7066; Abbey Green, nos. 5170a, 5249a; Farm Hill Works, no. 5455b. The collections grouped here are all similar in having the peristome teeth deeply inserted and free below (not united in a basal membrane as in *T. jamaicense*). The setae are yellow.

Tortella mollissima Broth. (ined.)

Near Sweetwater, St. James' Parish, nos. 2199a, 2201. This species is not included in the Pflanzenfamilien, and is evidently undescribed. It was

found named in a series of mosses collected by C. A. Purpus near Zacuapan, Mexico, which was sent to me from the University of California. Subsequent records from Cuba and Guatemala indicate that it has a rather wide distribution in the Caribbean regions.

Barbula orizabensis C.M.

Barbula recurvicuspes C.M.

Vicinity of Arntully, no. 6900.

This collection is representative of a considerable series from various localities. It is identical in every way with *B. orizabensis* from Mexico. I have not seen the type of *B. recurvicuspes*, but there is surely nothing in the description to indicate any distinction.

Desmatodon Sprengelii (Schwaegr.) Williams

Balaclava, on concrete wall, no. 625a; Phillip's Field, on bank, no. 1840a; near Kingston, on limestone, Feb. 12, 1927; along Black River, on earth, no. 7551.

New to Jamaica. This neat little moss, previously known only from the Dominican Republic and Florida, is an interesting addition to the Jamaican flora.

Aloinella apiculata Bartram, sp. nov. Fig. 2.

Dioica; caespitosa, caespitibus densiusculis, fuscescentibus. Caulis brevissimus, dense foliosus, simplex. Folia sicca incurvo-adpressa, humida erecto-patentia, rigida, e basi brevi lingulata, sensim acuta, apiculata, ad 2 mm. longa, marginibus inferne erectis, superne late inflexis, prope apicem denticulatis; costa applanata, dorso superne grosse papillata, ventre dense filamentosa; cellulae basilares rectangulares, parietibus fuscescentibus, superiores irregulariter transverse-elongatae, parietibus incrassatis. Folia perichaetialia minora, marginibus erectis, costa angustiori, sparse filamentosa; seta 10–12 mm. longa, rubra, laevissima; theca erecta, cylindrica, fusca, deoperculata 2 mm. longa; peristomii dentes breves, pallidi, erecti, dense papillosi, fere ad basin divisi, hic illic constricti, corona basilari ad 70μ alta; operculum conico-rostratum, 1.5 mm. longum; annulus 0; sporae $8–10\mu$ fuscidulae, laevissimae.

TYPE: Vicinity of Arntully, Nov. 1, 1928, *C. R. Orcutt*, 6802. Very distinct from *A. catenula* Card., of Mexico, in the leaf apex, which is apiculate by the excurrent costa (not rounded and helmet-shaped).

ORTHOTRICHACEAE

Zygodon Reinwardtii (Hornsch.) A. Br.

Blue Mountain, no. 3166. New to Jamaica. The range of this species in North America, as given in Malta's monograph (5), is limited to Mexico. This seems to be the only record of both the species and the genus in the West Indies.

CRYPHAEACEAE

Acrocryphaea Coffeae (C.M.) Par.

Newmarket, nos. 7277 and 7332; Darliston, no. 6218. New to Jamaica.

PTEROBRYACEAE

Pireella filicina (Hedw.) Card.

Vicinity of Arntully, no. 7062; Stony Valley River Gully, no. 5891. Apparently an uncommon species. It is sometimes difficult to separate from

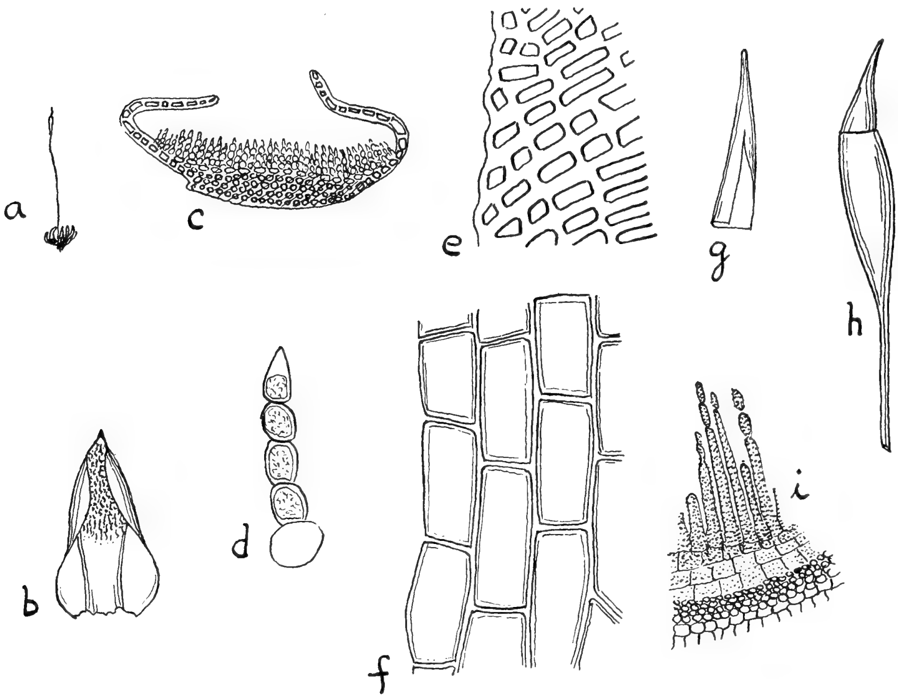

Fig. 2.—*Aloinella apiculata* Bartr., sp. nov.: *a*, plant ×1; *b*, leaf ×16; *c*, upper part of leaf in cross section ×80; *d*, costal filament ×400; *e*, upper leaf cells and margin ×400; *f*, basal leaf cells ×400; *g*, calyptra ×9; *h*, capsule ×9; *i*, part of peristome ×160.

Pterobryum angustifolium, but usually may be distinguished by the broader, more ovate branch leaves, which are deeply excavate under the apex, and by the shorter, oval cells of the upper part of the leaf. The leaves are also more inclined to be wrinkled and rugose when dry.

Pireella cavifolia (Card. & Herz.) Card.

Vicinity of Arntully, nos. 2764a and 5680a; Stony Valley River Gully, no. 5894. An interesting addition to the Jamaica flora. Previously known only from the type locality in Vera Cruz, Mexico.

METEORIACEAE

Pipillaria imponderosa (Tayl.) Broth.

Vicinity of Arntully, no. 2767; Blue Mountain Peak, no. 5305; Morce's Gap, no. 5573; Stony Valley River Gully, no. 5895. New to Jamaica.

Aerobryopsis longissima (Doz. & Molk.) Fleisch.

Aerobryopsis mexicana Card.

Vicinity of Arntully, no. 2832a. New to Jamaica. This collection is typical of the species in all respects. I am therefore well content to follow Cardot's opinion (3, 4) that *A. mexicana* and *A. longissima* are conspecific. Apparently *A. longissima* is exceedingly rare in North America, and known only from a single collection in Mexico and the one listed above from Jamaica.

NECKERACEAE

Homalia glabella (Hedw.) Mitt.

Moy Hall, no. 6832. A frequent species. The sporophyte characters have not, I think, been noted. The following description was made from plants in good fruit:

Seta slender, red, about 14 mm. long; capsule inclined, short-ovoid, 1.75 mm. long; lid conic-rostrate, oblique, as long as the urn; peristome teeth finely cross-striate, basal membrane of inner peristome about $\frac{1}{3}$ the height of the teeth, segments equalling the teeth, keeled, widely split along the median line, cilia one, appendiculate; spores smooth, 10–13μ.

Pinnatella jamaicensis Bartr.

Since the publication of this species (1) I have had an opportunity to compare the Jamaica plants with a specimen of *P. piniformis* (Brid.) named by Bescherelle (*Duss* 342 from Guadeloupe). That they are clearly distinct is unquestionable. The broadly rounded branch leaves of *P. jamaicensis* are in bold contrast to the sharply acute branch leaves of *P. piniformis*.

PILOTRICHACEAE

Pilotrichidium callicostatum (C.M.) Besch.

Many of the numerous collections of this species are from aquatic or subaquatic habitats to which the plants seem to be especially partial.

Diploneuron Bartr., gen. nov.

Pilotrichidia Besch. forsan affine, sed costis finis ad apicem folii in subulam longam acutam confluentibus.

Diploneuron connivens Bartr., sp. nov. Fig. 3.

Dioicum?; caespitosum, caespitibus sat densis, viridibus, haud nitidis. Caulis repens, hic illic radiculosus, irregulariter ramosus, ramis ad 1 cm. longis. Folia sicca erecto-patentia, saepe flexuosa, humida horride patula, e basi brevi oblongo-lanceolata, concava, acuminata, 3–4 mm. longa,

marginibus erectis, ubique minutissime crenulatis; costae binae prope medium folii, superne marginales, ad apicem in acumen attenuatum subulatum confluentes; cellulae superiores irregulares, saepe elongatae, parietibus incrassatis, sinuosis, circa 5μ latae et 12–25μ longae, hic illic bistratosae, basilares latiores, laxae, alares haud distinctae. Folia perichaetialia erecta, ad 2.5 mm. longa, caulinis sat similia sed celluis basilaribus laxioribus,

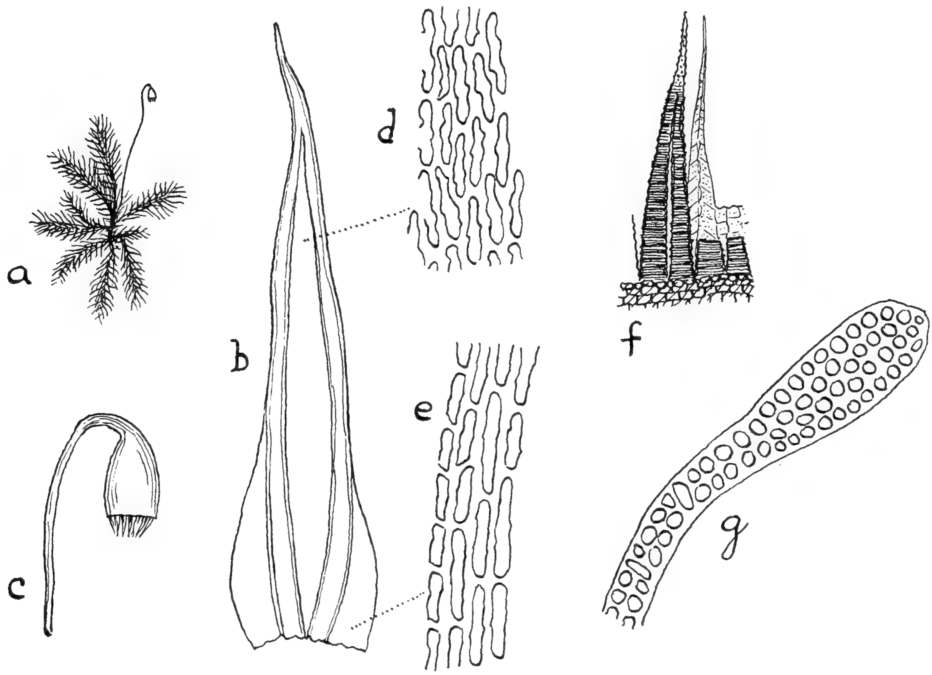

Fig. 3.—*Diploneuron connivens* Bartr., sp. nov.: *a*, plant ×1; *b*, leaf ×24; *c*, capsule ×9; *d*, upper leaf cells ×400; *e*, basal leaf cells ×400; *f*, part of peristome ×80; *g*, margin of upper part of leaf in cross section ×400.

rectangularibus, hyalinis; seta circa 2 cm. longa, laevissima, rubra; theca nutans, oblonga, fusca, 1.5 mm. longa; peristomium magnum, dentibus fuscis, trabeculatis, linea media exaratis, endostomio luteo, processibus carinatis, papillosis; calpytra sporogonii immaturi pallida, sparse pilosa; sporae laevissimae, 12–14μ.

Lumsden, St. Ann's Parish, 1928, *C. R. Orcutt* 6087 (type); Schwallenburgh, St. Ann's Parish, no 3942b.

I know of no other moss in which the costae become marginal in the upper half of the leaf and coalesce at the apex in a thickened, subulate point. Although similar to *Pilotrichidium* in sporophyte characters, the new genus is clearly unique in leaf structure.

In commenting upon this plant my friend M. Thériot suggested that it might be placed in the Pilotrichaceae. I feel that this is based on sound judgement and have adopted the suggestion, rather than follow my first inclination to include the genus in Hookeriaceae.

HOOKERIACEAE

Lepidopilum Mulleri (Hampe) Mitt.

Booby Woods, Moy Hall, nos. 6876 and 6930; vicinity of Arntully, no. 5774. New to Jamaica.

THUIDIACEAE

Anomodon Wrightii C.M.

Vicinity of Arntully, no. 3840. The above is the only gathering of this species that I know of since the original collection in Cuba by Wright. The slender, julaceous branches and entire leaves may be constant characters, but it comes uncomfortably close to *A. attenuatus* (Hedw.) Huben.

Anomodon rostratus (Hedw.) Schp.

Vicinity of Arntully, no. 3185; Westphalia (Cedar Hurst), no. 3762; Blue Mountain, no. 2854. New to Jamaica.

Thuidium minutulum (Hedw.) Bry. eur.

Thuidium Wrightii Jaeg.

Moy Hall, no. 6892; vicinity of Farm Hill, no. 3671. Abundantly represented in Jamaica by numerous collections in rich fruit. The two numbers listed above are representative. I fail to find any distinguishing characters at all in *T. Wrightii* Jaeg. Like *Anomodon rostratus, Campylium chrysophyllum,* and *Tortula agraria,* the range of *T. minutulum* (Hedw.) includes the southeastern United States, Cuba, and Jamaica.

AMBLYSTEGIACEAE

Platyhypnidum aquaticum (Hampe) Fleisch.

Stony Valley River Gully, no. 5877. New to Jamaica.

BRACHYTHECIACEAE

Scleropodium purum (Hedw.) Limp.

Cinchona, 1928, no. 5492c. Apparently introduced from Europe.

Rhynchostegium argute-serratum Bartr., sp. nov. Fig. 4.

Autoicum, gracilescens, caespitosum, caespitibus densis, depressis, viridibus, nitidiusculis. Caulis elongatus, parce fusco-radiculosus, repens, irregulariter pinnatim ramosus, ramis patulis, haud complanatis, cum foliis ad 2 mm. latis, breviter attenuatis. Folia ramea patula, ovato-lanceolata, acuminata, concaviuscula, ad 1 mm. longa marginibus basi leviter recurvis, superne erectis, ubique argute serratis; costa supra medium folium parum superans; cellulae superiores rhomboideo-lineares, circa 7–8μ latae, laevissimae, basin versus laxiores, alares haud distinctae. Folia perichaetialia erecto-appressa; seta tenuis, laevissima, rubra, circa 1.5 cm. longa; theca oblonga, inclinata, 1.3 mm. longa, sub ore constricta, aetate nigrescens, exothecii rete laxo, e cellulis rectangularibus, peristomium typicum; operculum e basi conica longe et oblique subulatum; sporae laevissimae, 15μ

Farm Hill, no. 3749a; Moy Hall, no. 6875; Booby Woods, Moy Hall, nos. 6957, 6962 (type).

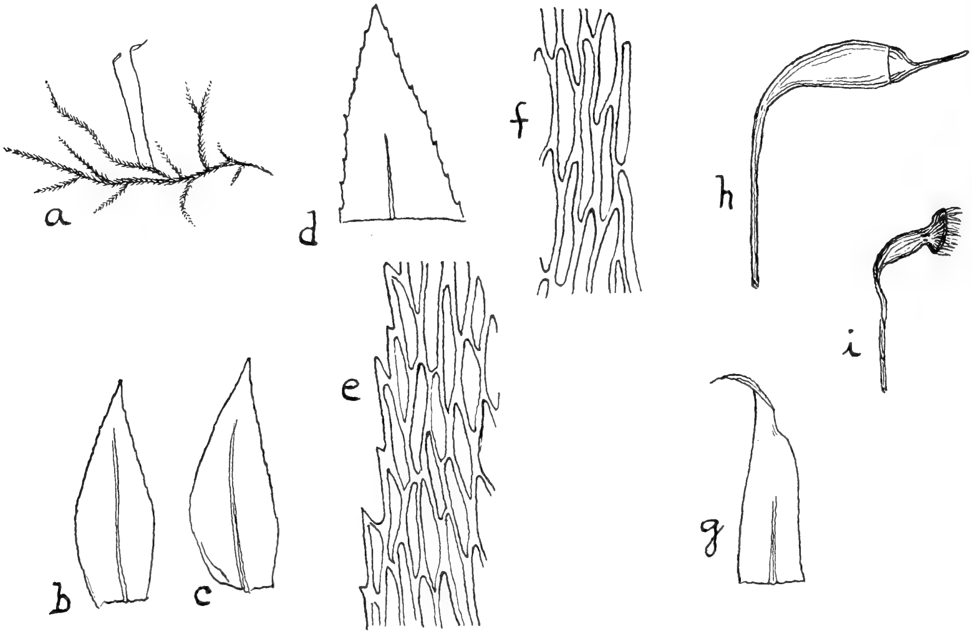

Fig. 4.—*Rhynchostegium argute-serratum* Bartr., sp. nov.: *a*, plant ×1; *b*, *c*, leaves ×30; *d*, apex of leaf ×80; *e*, upper leaf cells and margin ×400; *f*, basal leaf cells ×400; *g*, perichaetial leaf ×30; *h*, moist capsule ×9, *i*, dry capsule ×9.

A rather slender, delicate species for the genus. It may be distinguished from *R. scariosum* (Tayl.) by the vivid green color, less finely pointed leaves, shorter areolation, and sharply serrate margins. The deep red setae are also characteristic.

ENTODONTACEAE

Platygyriella jamaicensis Bartram, sp. nov. Fig. 5.

Autoica; gracilis, lignicola, caespitosa, caespitibus mollibus, densis, pallide viridibus, nitidiusculis. Caulis repens, fragilis, hic illic sparse sed longe fusco-radiculosus, subpinnatim ramosus, ramis 1–1.5 cm. longis. Folia erecto-patentia, ovato-lanceolata, concava, breviter acuminata, ecostata vel brevissime bicostata, ad 1.4 mm. longa, marginibus integerrimis, superne erectis, inferne anguste recurvis; cellulae lineares, pellucidae, infimae laxiusculae, ad angulos paucae, laxae, subquadratae vel rectangulares, omnes laeves. Folia perichaetialia erecto-patentia, integerrima; seta 4–6 mm. longa, tenuis, laevissima; theca erecta, oblongo-cylindrica, deoperculata ad 1.4 mm. longa, fusca; exostomii dentes subulato-lanceolati, fusci, superne grosse papillosi, inferne transverse striolati; endostomium fuscidulum, corona basilari humili, processibus anguste linearibus, papillosis: operculum conico-rostratum, ad 0.4 mm. longum; sporae 15–20μ, luteae, minutissime punctulatae.

TYPE: Newmarket, Dec. 12, 1928, *C. R. Orcutt* 7263.

Although the group of cells at the leaf angles is small, lax, and poorly defined, as contrasted with the distinct group of quadrate alar cells in *P. helicodontoides* Card., the peristome structure is in close accord. As the sporophyte characters are of prime importance in this group I feel that the Jamaican plants may be safely placed here.

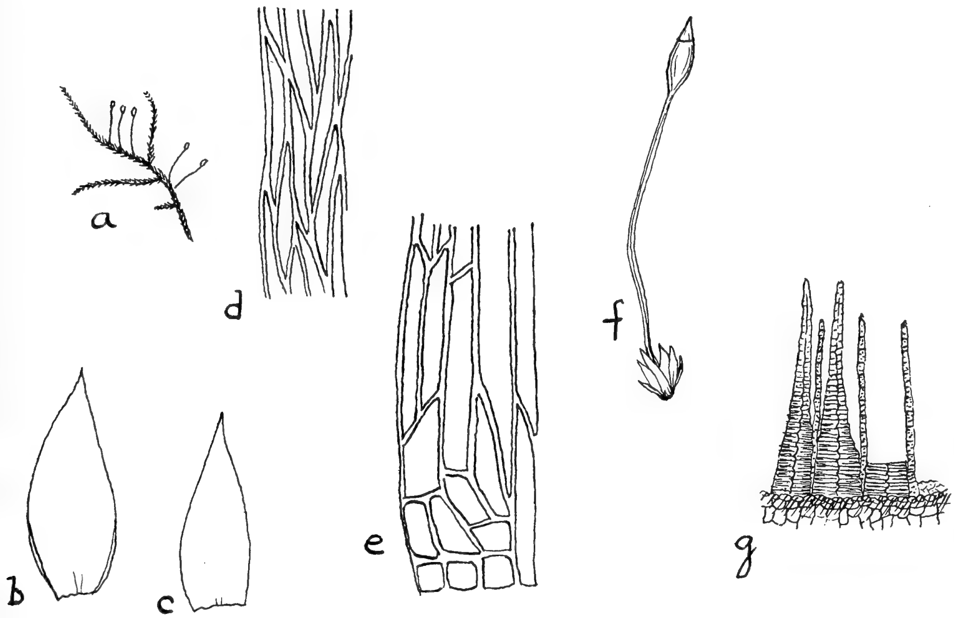

Fig. 5.— *Platygyriella jamaicensis* Bartr., sp. nov.: *a*, plant ×1; *b*, *c*, leaves ×30; *d*, upper leaf cells and margin ×400; *e*, basal angle of leaf ×400; *f*, sporophyte ×9; *g*, part of peristome ×160.

M. Thériot is in accord with me in thinking that the genera included by Brotherus in the subfamily Pylaisioideae, under Hypnaceae, with the possible exception of *Homomallium*, would find a more congenial resting place in Entodontaceae, between which family and Hypnaceae it evidently occupies a transitional position.

POLYTRICHACEAE

Atrichum angustatum (Brid.) Bry. Eur. var. **Mulleri** (Schp.) Bartr. comb. nov.

Atrichum Mulleri Schp.

Farm Hill, nos. 3367 and 3392; Portland Gap, no. 5413. For remarks on this see the note on page 361 of Honduran Mosses (2).

Oligotrichum erosum (Hampe) Lindb.

Blue Mountain, nos. 2910 and 2911. New to Jamaica.

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ZOOLOGY.—*Some West American sea anemones.*[1] Oskar Carlgren, University of Lund, Sweden. (Communicated by Waldo L. Schmitt.)

The present paper is based on material collected in California and Washington by Mr. E. F. Ricketts of the Pacific Biological Laboratory, who has long been interested in the Pacific Coast marine invertebrates. Two species taken by Professor T. Gislén, Lund, during a visit to California in 1931 are included. Three species are, I think, not previously described. Instead of the sub-tribe Protostichodactylinae, I have erected a tribe, Corallimorpheae.

Tribe CORALLIMORPHEAE, new name

As I have pointed out previously (1924, p. 180), I cannot agree with the opinion of some authors that the family Corallimorphidae, as well as all other Protostichodactylinae, belong to the Madreporaria. If we place them together, we must suppose that in the Protostichodactylinae the skeleton is lost or never has been developed. The first hypothesis, I think, we can leave out of consideration, because no traces of a skeleton have been found in the Protostichodactylinae, most of which live in shallow water, especially on coral reefs. On the other hand, supposing that the Protostichodactylinae never have been provided with a skeleton, we must consider them as descendants of forms from which the Actiniaria, as well as the Madreporaria, have arisen, for the supposition that the Madreporaria originate from the Protostichodactylinae is hardly probable. Moreover, we cannot indicate to which family of Madreporaria the latter group is allied. For my part, I am more inclined to consider the Protostichodactylinae as having developed parallel to the Madreporaria and the Protantheae (s. str.) among the Actiniaria having relations to both these groups. Perhaps an order, Corallimorpharia, equal to the Actiniaria and Madreporaria, should be erected for the Protostichodactylinae, but for the present I prefer to place them as a group, Corallimorpheae, among the Actiniaria. The name Protostichodactylinae is misleading, because on the one hand forms with the tentacles

[1] Received August 15, 1935.

not arranged in radial series must be referred to the Protostichodactylinae, and on the other that the so-called Stichodactylinae are not descendants of this group. I divide the Actiniaria then into five tribes: Protantheae (s. str.), Corallimorpheae, Ptychodacteae, Endocoelantheae, and Nynantheae.

Family CORALLIMORPHIDAE

Corynactis californica n. sp.

Diagnosis.—Sphincter elongated weak. Tentacles large, especially those belonging to the exocoels. Endocoel-tentacles in each radius 2–5; 2 siphonoglyphs, little differentiated, and two pairs of directives (always?). Longitudinal muscles of the mesenteries rather weak. Macrocnidae of the column (38) 43–53×11–12μ rather common those of the heads of the tentacles 68–83×12–14μ, those of the actinopharynx 34–42×10 (11)μ, those of the filaments partly 76–86×24–26μ, partly 38–60×12–17μ; elongated cnidae with distinct basal part to the spiral thread in the column partly 43–48×10μ (few), partly 14–25×2.5–5μ (common), those of the heads of the tentacles 35–62×4–6μ and 29–34 (53)×4.5–5μ, those of the actinopharynx 26–29 ×3.5–4μ those of the filaments partly 33–43 (48)×8.5–10μ, partly 22–29 ×6–7μ. Spirocysts (spirocnidae) of the column rather sparse, 19–24×2.5–3.5μ, those of the heads of the tentacles 24×2–about 60×5μ, those of the actinopharynx 20–26×2.5–3μ.

Color in formalin.—Column brown, other parts uncolored.

Dimensions of the largest specimen.—Largest breadth and length 1.3 cm.

Occurrence.—California, Monterey Bay 6–8 fms., June 3, 1934, 6 specimens; June 11, 1934, 1 specimen. Holotype, U. S. N. M. Cat. No. 43060.

The exterior agrees with that of other *Corynactis* species. The endocoel-tentacles varied in each radius between 2 and 5. In a specimen pierced by a Gephyrean, probably swallowed alive by the sea anemone, the number of the endocoel-tentacles in each radius was as follows: 5, 3, 2, 5, 2, 4, 2, 4, 2, 4, 2, 3, 2, 2, 2, 2, 4, 2, 4, 2, 5, 2, 4, 5, 2, 4, 2, 4, 3, 4, 2, 3, 2, 4, 3. Between each of these radii and inside the outermost endocoel-tentacles one large exocoel-tentacle was situated. The sphincter was very elongated and rather weak (fig. 1), the actinopharynx provided with numerous high longitudinal ridges. There were 2 slightly differentiated siphonoglyphs. The mesenteries were, in the sectioned specimen, 72 in the middle of the actinopharynx, 34 on one side, 38 on the other; 10 pairs and 3 single mesenteries were perfect; 2 pairs were directives. Moreover, the anatomy of the species agrees with that of other species of *Corynactis.* The measurements of the cnidae and the heads of the tentacles have been made on the largest specimen, taken June 3. I have called the large broad capsules macrocnidae, as they seem to agree with those of the Zoantharia (compare Seifert 1928). The more elongated capsules (c, c_1, capsules Carlgren, 1928, p. 131) seem to be of the same appearance as those figured by Möbius (1866, Pl. 1, figs. 5, 6) of *Caryophyllia.* The basal part of the spiral thread reminds one of that of a penicillus, but the terminal thread, at least 10 times as long as the capsules, seems to be provided with very small bristles, not figured in fig. 2. There were no zooxanthellae in the endoderm.

It is very difficult to give good diagnoses of the species of *Corynactis*, as they agree very much in their structure. The species cannot be identical with the West Indian *C. bahamensis* and *C. myrcia*. if Duerden's (1900, p. 182) statement of the arrangement of the tentacles of the latter is correct, and probably not with *C. carnae*, which is unknown on the west coast of Central America and has not been taken north of Guaytecas Islands on the west coast of South America.

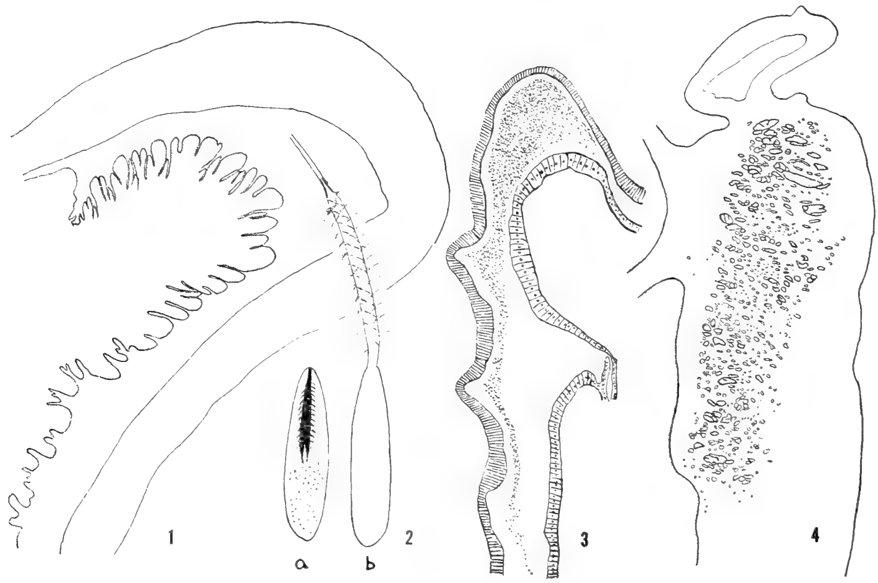

Fig. 1.—*Corynactis californica*. Sphincter. Fig. 2.—*Corynactis californica*. Cnidae: *a*, unexploded; *b*, exploded. The basal part and a little piece of the long terminal thread are figured. Fig. 3—*Amphianthus californicus*. Sphincter. Fig. 4.—*Stephanauge annularis*. Sphincter.

Tribe NYNANTHEAE

Family EDWARDSIIDAE

Edwardsia californica (McMurrich)

Edwardsiella californica McMurrich, Proc. U. S. Nat. Mus. **44**: 551, fig. 1. 1913.

Diagnosis— Physa well developed. Scapus with 8 rows of rather large nemathybomes polygonal. Tentacles 16. Pennons of the macrocnemes on cross-sections elongated with about 30–40 folds, not especially high, branched in the inner and especially in the outer part, with a palisade-like arrangement in the middle. Outer lamellar part of the macrocnemes in the reproductive region attached to the pennon rather close to its center. Parietal muscles very well developed, fan-like or more rounded, with about 8–10 branched folds on either side of the main lamella. Extension of the parietal muscles on the column normal. Nematocysts of the actinopharynx partly $29–34 \times 2.5–3\mu$ (numerous spirulae), and partly $24–31 \times$ about 5μ (probably penicilli, considerably fewer); those of the nemathybomes partly $115–153 \times 6.5–7\mu$, and partly $72–77 \times 2.5\mu$.

Dimensions.—Length 2.2 cm., breadth 0.3 cm.

Occurrence.—Balboa, California. Littoral. T. Gislen, 1931.

The figure given by McMurrich of a pennon and a parietal muscle agrees very well with what I have seen from the sections through the upper part of the reproductive region; the folds of the pennons in our specimen were somewhat fewer, those of the parietal muscles somewhat more numerous, but the appearance of the muscle-folds showed good agreement in both specimens. McMurrich mentions that the nemathybomes stand in two or three rows in the proximal end of the scapus. Certainly this arrangement was caused by contraction; in our specimen the scapus was provided with only 8 rows of nemathybomes. The specimen was a female.

Family HALCAMPOIDIDAE

Harenactis attenuata Torrey

Herenactis attenuata Torrey, Proc. Wash. Acad. Sci. **4:** 384, pl. 24, figs. 4, 5, text-figs. 16, 17. 1902.

Occurrence.—Newport Bay, California, low water, sand. T. Gislen, 1931, several specimens.

I have measured the cnidae of a large specimen. The nematocysts of the column were very numerous, 8–14×1.5–2μ; those of the tentacles numerous, rodlike, 17–22×1.5–2μ; those of the actinopharynx 24–27×2.5μ (spirulae), and 19–22×3–4.5μ (penicilli); those of the filaments 16–24×4–5μ penicilli—2 rodlike nematocysts 19–22×2.5μ, spirulae?). Spirocyst of the tentacles 10×1–19×2μ.

Family HALCAMPIDAE

Halcampa duodecimcirrata (M. Sars)?

Halcampa duodecimcirrata M. Sars. Carlgren, K. Vet. Akad. Handl., **(25) 10:** 38, pl. 5, figs. 1–5 pl, 6, figs. 1, 2. Stockholm, 1893. Danish Ingolf Exped. **(5) 9:** 119, pl. 4, fig. 8. 1921. Verril, Rept. Canadian Arctic Exped. 1913–18, P. G: 120, pl. 21, figs. 1, 2, 2a, var. *nitida*, p. 121.

Dimensions of the largest specimen.—Length 1.7 cm., breadth of its lower part 0.2, of its upper 0.3 cm. Length of the tentacles 0.2 cm. Dimensions of the smallest specimen: Length 1.2 cm., breadth 0.25 cm.

Occurrence.—Pysht, Washington, June 26, 1930, 2 specimens.

The column was broader in the distal than in the proximal end, the physa contracted, the scapus in its lower part somewhat incrusted with sand. I cannot decide whether there were real tenaculi here, as I have sectioned only the upper part of a specimen. Here no tenaculi were present. The tentacles, in number only 10, were robust and, in the contrasted state, somewhat acuminated. The sphincter had the same size and appearance as that of other *Halcampa* species. There were 20 mesenteries, 10 of which had well developed pennons and were probably perfect—the inner organs were not well preserved. The mesenteries of the sixth pair, as well as the dorsolateral and lateral pairs of the second order were imperfect; the ventrolateral pairs of the second order were absent. The cnidae agree rather well

with those of *farinacea*. The nematocysts of the scapus were 11–12× about 1.5μ (not numerous); those of the scapulus 11–13×2–2.5μ; those of the tentacles 12×2μ (very sparse); those of the actinopharynx 19–24×(4.5)–5μ (probably penicilli). Spirocysts of the scapulus very numerous, about 14×1.5–25μ; those of the tentacles 14×1–1.5–31×2–2.5μ.

It is very difficult to give good diagnoses of the species of *Halcampa* and it is possible that *duodecimcirrata* and *farinacea* are identical species but probably not *chrysanthellum*, as the tentacles of this species, according to Stephenson's figure 3, pl. 2 (1928), are conical, while those of *duodecimcirrata* are cylindrical. I have never seen the tentacles of the latter species so acuminated as in *chrysanthellum*, though I have examined many specimens of the former which lived for a long time in my aquaria.

The species of the genus *Halcampa* live, it seems, only in the arctic, subantarctic, and boreal regions; at least there are no species from tropical seas. The largest species occur in the Arctic and this raises the question of whether *H. arctica* is not an ancestor of *duodecimcirrata* which often has 8–10 tentacles in the boreal region. If so, there is nothing astonishing in the fact that *duodecimcirrata*, which Verrill records from the east coast of North America—his variety *nitida* had also 10 tentacles—occurs in the North Atlantic as well as in the North Pacific. We have, then, a parallelism with *Tealia* (*Urticina*) *felina*, the variety *coriacea* (or *tuberculata*) of which occurs in both these seas and the ancestor of which certainly is *T. felina crassicornis* (compare Carlgren 1934, p. 349).

Cactosoma arenaria Carlgren

Cactosoma arenaria Carlgren, Arkiv f. Zool. (23A.) **3**: p. 39, fig. 36. Stockholm, 1931.

Occurrence.—Monterey Bay, California, 6–8 fms., June 3, 1934, 1 specimen.

The specimen was provided with a physa, the scapus with tenaculi and incrustations. The tentacles were 24, agreeing with the number of mesenteries. The nematocysts of the scapulus (capitulum) were 8–10×1μ, those of the tentacles 12–13× about 1.5μ; those of the actinopharynx partly 24–29×3.5–4.5μ (probably penicilli), and partly 14–15× about 1.5μ (rare, often curved, probably spirulae). The spirocysts of the tentacles were 14–29 ×1.5–3μ, thus showing a good agreement with the cnidae of the type specimen.

Family NORMATHIIDAE

Amphianthus californicus n. sp.

Diagnosis.—Pedal disc very wide. Column smooth, without tubercles, thin. Only one cinclis, not situated on a tubercle issuing from the directive chamber (sometimes absent?) Sphincter strong, alveolar, consisting of very small meshes, in its upper part occupying the greater part of the meosgloea, in its lower gradually diminishing. Tentacles to about 100, rather short, the inner more than twice as large as the outer ones. Actinopharynx with about

14 longitudinal ridges. One siphonoglyph (always?). Mesenteries at the limbus about twice as many as those at the margin. A single directive pair (always?). More than 6 pairs of perfect mesenteries. Arrangement of the mesenteries irregular. Reproduction probably also by tearing of the limbus. Nematocysts of the column $17–20\times3.5–4$ $(4.5)\mu$ (penicilli), and $19–24\times2.5$–almost 3μ (probably spirulae); those of the tentacles $17–22$ $(28)\times3.5$ $(5)\mu$ (penicilli), $12–14\times2.5\mu$ (probably penicilli), and $19–26\times2.5\mu$ (spirulae); those of the actinopharynx $17–20.5\times3.5$ (penicilli), $20–22\times2–2.5\mu$ (probably spirulae); those of the acontia $26–31\times4–4.5$ $(5)\mu$ (spirulae). Spirocysts of the tentacles to about $48\times6\mu$.

Color in alcohol.—Yellowish, around the mouth a brownish annulus.

Dimensions.—The largest specimen was 1.3 cm. high, the breadth of the oral disc 1.2 cm., the folded pedal disc considerably broader; another sectioned specimen 0.8 cm. high and 0.6 cm. broad, the pedal disc considerably broader.

Occurrence.—Monterey Bay, California; C.Y. Rock, June 11, 1934, 12 specimens. Some of these attached to a Hydrocoral. Holotype, U. S. N. M. Cat. No. 43061.

The pedal disc was very broad and mostly rather strongly folded, the column thin and smooth, with weak transverse furrows due to contraction. No cinclis was observed in cross-sections of a smaller specimen, but on sections of a piece of the column of the largest specimen (fig. 3) corresponding to the directive chamber I have found a cinclis almost wholly excavated from the endoderm. This cinclis was not situated on a distinct tubercle. The tentacles, in the largest specimen about 98, in the smaller specimens fewer, were rather short, especially the outer ones, which were less than half as large as the inner tentacles. The oral disc was wide with visible insertions of the mesenteries. Seven specimens had a single, rather broad siphonoglyph. I have not examined the smallest specimens. The actinopharynx of the largest specimens was provided with about 14 distinct and some more weakly developed longitudinal ridges.

The ectoderm of the column was low, with numerous gland cells, the mesogloea rather thin, the sphincter (fig. 4) long, broad in its upper part, gradually diminishing toward the pedal disc, and at the same time approaching the ectoderm, with very fine muscle meshes and wholly separated from the endodermal muscles of the column. The longitudinal muscles of the tentacles and the radial muscles of the oral disc were ectodermal, normally developed and with a palisade-like arrangement. The ectoderm of the actinopharynx was somewhat thicker than that of the column, the ridges mostly thickenings of the ectoderm. The cilia of the siphonoglyph was longer than in the other part of the actinopharynx.

The mesenteries were about twice as numerous as the tentacles. In a specimen with 52 tentacles I counted about 110 mesenteries at the limbus. A sectioned specimen had 9 pairs of perfect mesenteries, including a pair of directives. Judging from the insertions of mesenteries on the oral disc, there were more than 20 perfect mesenteries in the largest specimen. The pennons and the parietobasilar muscles were very weak in the sectioned specimen,

which seems to be sterile. As I have not wished to destroy the largest specimen, I cannot give any information as to the distribution of the generative organs which may be developed in it. The ciliated streaks of the filaments were well developed, as were also the thick acontia. The nematocysts of the tentacles and acontia were measured in 2 specimens.

The species agrees rather closely with *A. dohrni*, as well as with a new species from Drontheim fjord, but is certainly distinct.

Stephanauge annularis n. sp.

Diagnosis.—Pedal disc clasping stems of *Balticina* and forming an annulus around the stem. Column smooth, 1+1 cinclides on distinct tubercles. Sphincter strong, but short, reticular-alveolar, its proximal end truncate. Tentacles of ordinary length to about 96, the inner considerably longer than the outer ones. Two deep siphonoglyphs. Mesenteries probably fewer in the proximal part than at the margin, at any rate not more numerous; 48 pairs of mesenteries, 6 pairs perfect, 2 pairs of directives. All mesenteries, with the probable exception of the directives, fertile. Acontia? Nematocysts of the actinopharynx $15–18\times3.5–4\mu$ (penicilli); those of the filaments $14–17\times3.5–4\mu$ (penicilli). Spirocysts of the tentacles $19\times2.5–36\times5.5(6)\mu$.

Dimensions.—Largest specimen about 1 cm. broad, greatest height about 1.5 cm.

Occurrence.—Monterey Bay, California, on *Balticina*, 70 fms., June 26, 1930, several specimens, badly preserved. Holotype, U. S. N. M. Cat. No. 43062.

The pedal disc encircled stems of *Balticina*, therefore the Actinia, when separated from its host, has the appearance of an annulus, from which a

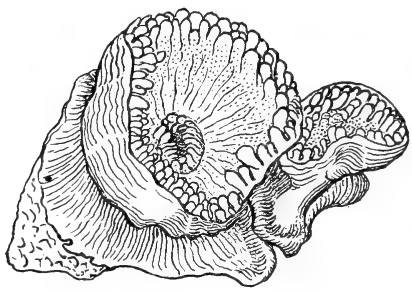

Fig. 5.—*Amphianthus californicus*, natural size.

low cylinder arises. The specimens occurred in groups, in which they stand very close to each other. The mesogloea of the smooth column was thick, the ectoderm lost. There were 1+1 cinclides in the best preserved specimen. The conical tentacles were about 96, in some specimens the outer part of the oral disc was radially furrowed. Two more closely examined specimens had 2 deep siphonoglyphs situated perpendicularly to the stem of *Balticina*.

Owing to the bad preservation of the specimens, a perfect description of their anatomy cannot be given. The sphincter was strong, reticular-alveolar, not elongated, with rather large meshes (fig. 5). The actinopharynx was

provided with longitudinal ridges caused by the swellings of the mesogloea, in the smaller, sectioned specimen 12, in the largest about twice as many. The mesogloea of the actinopharynx was thick.

The pairs of mesenteries were in one specimen 48 in the upper part, in another about 48. I cannot decide with certainty how many were present at the pedal disc, but probably they were fewer here or present perhaps in the same number as at the margin; at any rate, they were not more numerous at the limbus. Two sectioned specimens had 2 pairs of directives; 6 pairs were perfect. The longitudinal muscles of the mesenteries were weak, somewhat stronger on the directives. All mesenteries were fertile, with the probable exception of the directives. The filaments of the mesenteries were very poorly preserved, mostly dissolved; the whole coelenteric cavity was filled up by the testes. I have not found any acontia; probably they were few in number. As to the nematocysts of the tentacles and column I am not able to give any information, as the ectoderm of these organs was almost entirely lost.

Family METRIDIIDAE

Metridium senile (L.) var. **fimbriatum** (A. E. Verrill)

Occurrence.—Sitka, August 2, 1932, 1 specimen; Whale Island near Sitka, August 17, 1932, 1 specimen.

I have examined the nematocysts of the acontia in both specimens. The Penicilli were $41–50 \times 5\mu$ and $54–60 \times 5\mu$ respectively; the spirulae, 43–58, mostly $50–53 \times 4–4.5\mu$ and $58–62 \times 4–4.5\mu$ respectively. The specimens were respectively 0.8 and 0.4 cm. high, the breadth of the pedal disc 0.9 and 0.55 cm.

I take the opportunity to rectify a lapsus in my paper *Some Actiniaria from Bering Sea and arctic waters* (1934, p. 353). Where I have written "var. *marginatum*" read "var. *fimbriatum*."

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ZOOLOGY.—*Revision of the bathypelagic prawns of the family Acanthephyridae, with notes on a new family, Gomphonotidae.*[1] FENNER A. CHACE, JR., Museum of Comparative Zoology. (Communicated by WALDO L. SCHMITT.)

Owing to difficulties at this time in the publication of these observations in monographic form as was the original intention, it has seemed advisable to present an abstract of that data in the form of a key to the species of the family with one important reference for each species, together with the synonyms of each. Inasmuch as many of these forms are cosmopolitan, it is deemed unnecessary to discuss the distribution of the group at this time.

The material covered has been drawn from the collections in the Museum of Comparative Zoölogy and the U. S. National Museum made by the U. S. Steamers *Blake* and *Albatross* and the auxiliary ketch *Atlantis* of the Woods Hole Oceanographic Institution.

This opportunity is taken to acknowledge the invaluable assistance offered to me by the staffs of the Museum of Comparative Zoölogy and the U. S. National Museum, without which this paper would have been impossible. I wish to thank especially Dr. Hubert Lyman Clark, Dr. Elisabeth Deichmann, Dr. Thomas Barbour, and Dr. Henry B. Bigelow of the Museum of Comparative Zoölogy and Dr. Waldo L. Schmitt, Dr. Mary J. Rathbun, and Mr. Clarence R. Shoemaker of the U. S. National Museum.

The Acanthephyridae may be defined as that group of the Decapoda Natantia in which the first two pairs of pereiopods or "walking legs" are chelate, similar, of moderate size, and with an undivided carpus; the last three pairs of pereiopods are neither chelate nor abnormally long; all the pereiopods are provided with an exopod; there is no lash on the exopod of the first maxilliped; and the mandibles are imperfectly cleft.

The seven genera and 59 species and varieties listed by de Man in 1920 are here reduced to six genera and 44 species.

The genus omitted is *Gonatonotus*, of which there is but one species, *G. crassus* A. Milne Edwards, 1881. Although only two specimens of this aberrant form have heretofore been recorded, it has been my privilege to examine no less than 13 specimens, many of them from the Philippine region, despite the fact that the species had not been previously recorded from the Pacific. An examination of the mouthparts disclosed that the mandible is composed of but one lobe and

[1] Received August 27, 1935.

the exopod of the first maxilliped is provided with a long lash very similar to that found in the Pandalidae. Inasmuch as this character completely excludes this prawn from the Acanthephyridae, and the undivided carpus of the second pair of pereiopods prevents uniting it with the Pandalidae, it is proposed that this form be placed in a separate family. Since the name *Gonatonotus* is preoccupied for a genus of Parthenopid crabs (White, Proc. Zool. Soc., London, **15**: 58, 1847), I suggest the name **Gomphonotus**[2] for the genus of prawns, and the family may then be known as the **Gomphonotidae.**

Eleven species not examined by the author have been marked with an asterisk (*) in the key below.

KEY TO THE GENERA OF THE ACANTHEPHYRIDAE

1. Exopods of at least the third maxillipeds and first pair of pereiopods foliaceous and generally rigid; outer margin of antennal scale usually armed with a series of spines; telson not truncate at tip, but ending in a sharp point; eyes large and well pigmented....Genus 6. *Oplophorus*
   None of the exopods of the pereiopods foliaceous or rigid............2
2. Last four abdominal somites, at least, carinate along dorsal midline.. 3
   Sixth abdominal somite never dorsally carinate......................4
3. No straight ridge or carina running entire length of lateral surface of carapace from orbit to hind margin along median lateral line; hind margin of hepatic furrow not cut off abruptly by an oblique ridge or carina; incisor process of mandible toothed for its entire length...... ....Genus 1. *Acanthephyra*
   Carapace decorated with at least one straight carina traversing the lateral surface from hind margin of orbit to posterior edge of carapace; hind margin of hepatic furrow abruptly cut off from branchial region by an oblique carina; anterior half of incisor process of mandible unarmed.. ....Genus 2. *Notostomus*
4. Ischial and meral joints of pereiopods very broad and much compressed laterally................................Genus 3. *Ephyrina*
   Pereiopods normal...5
5. Eyes very small and poorly pigmented; anterior margin of first abdominal somite entire, not toothed; telson terminating in a truncate, spinose tip....................................Genus 4. *Hymenodora*
   Eyes very large and well pigmented; anterior margin of first abdominal somite armed with a distinct lobe or tooth overlapping hind margin of carapace; telson terminating in a sharp-pointed end-piece laterally armed with spines........................Genus 5. *Systellaspis*

[2] γομφος, νοτος.

Genus 1. ACANTHEPHYRA A. Milne Edwards, 1881

KEY TO THE SPECIES OF ACANTHEPHYRA

1. Posterior third, at least, of carapace not dorsally carinate............2
   Carapace dorsally carinate throughout its length.................13
2. Integument thin and soft.................................3
   Integument hard and firm.................................7
3. Carina supporting branchiostegal spine not reaching to posterior half of carapace...4
   Carina supporting branchiostegal spine reaching almost or quite to hind margin of carapace.......................................6
4. Rostrum very high and laterally compressed to a thin crest; small spine on third abdominal somite (See: Balss, 1925, p. 262)................. ....*A. tenuipes* (Bate,1888)*
   (=*Tropiocaris tenuipes* Bate, 1888)
   Rostrum depressed, not thin and high..........................5
5. Large, laterally compressed spine on third abdominal somite reaching to posterior third of fifth somite (See: Lenz and Strunck, 1914, p. 327).. ....*A. brevirostris* Smith, 1885.
   (=*Hymenodora duplex* Bate, 1888)
   No spine on third abdominal somite (See: Kemp, 1906, pp. 19 and 23) ....*A. rostrata* (Bate, 1888)*
   (=*Hymenodora rostrata* Bate, 1888)
6. Rostrum little more than half as high as long (See: Balss, 1925, p. 264) ....*A. indica* Balss, 1925.*
   (=*Acanthephyra* sp. de Man, 1920)
   Rostrum higher than long (See: Balss, 1925, p. 262)................. ....*A. cucullata* Faxon, 1893.
7. Telson dorsally sulcate on proximal portion.......................8
   Telson dorsally ridged on proximal portion.......................12
8. Carina supporting branchiostegal spine very prominent and reaching to anterior margin of branchial region..........................9
   Carina supporting branchiostegal spine, if present, short and obscure.. 10
9. Rostrum less than half as long as carapace (See: Balss, 1925, p. 261).. ....*A. curtirostris* Wood-Mason, 1891.
   (=*A. acutifrons* Bate, 1888, part)
   Rostrum more than three-fourths as long as carapace (See: Bate. 1888, p. 736)...................................*A. media* Bate, 1888.
   (=*A. media* var. *obliquirostris* de Man, 1916)
10. Eyes minute, very much narrower than eyestalks (See: Alcock, 1901, p. 80)............................*A. microphthalma* Smith, 1885.
    (=*A. longidens* Bate, 1888)
    Eyes normal, slightly broader than eyestalks.....................11

11. Branchiostegal spine supported by a short carina (See: Stephensen, 1923, p. 44) . . . . *A. purpurea* A. Milne Edwards, 1881.
(=*Miersia agassizii* Smith, 1882; *A. sica* Bate, 1888; *A. acanthitelsonis* Bate, 1888; *A. kingsleyi* Bate, 1888; *A. rectirostris* Riggio, 1900; *A. purpurea*, var. *multispina* Coutière, 1905; *A. parva* Coutière, 1905; *A. haeckeli* Thiele, 1905; *A. batei* Stebbing, 1905)
Branchiostegal spine minute and supported by neither carina nor ridge (See: Balss, 1925, p. 256) . . . . *A. sanguinea* Wood-Mason, 1892.
12. No carina supporting branchiostegal spine (See: de Man, 1920, p. 61) . . . . *A. armata* A. Milne Edwards, 1881.
Prominent carina supporting branchiostegal spine (See: Wood-Mason and Alcock, 1894, p. 156) . . . . *A. fimbriata* Wood-Mason, 1894.
(=*A. armata* var. *fimbriata* Wood-Mason, 1894; *A. armata* (part) of many authors)
13. First abdominal somite dorsally carinate 14
First abdominal somite not dorsally carinate 16
14. Hepatic spine on carapace (See: Balss, 1925, p. 260) . . . . *A. corallina* (A. Milne Edwards, 1883)
(=*Notostomus corallinus* A. Milne Edwards, 1883; *Acanthephyra valdiviae* Balss, 1914)
No hepatic spine on carapace 15
15. Telson dorsally grooved (See: Balss, 1925, p. 261) . . . . *A. acutifrons* Bate, 1888.
Telson distinctly ridged on proximal half (See: Balss, 1925, p. 257) . . . . *A. carinata* Bate, 1888.
16. Telson dorsally ridged 17
Telson dorsally grooved 19
17. Rostrum armed dorsally almost to tip (See: Faxon, 1895, p. 162) . . . . *A. approxima* Bate, 1888.
Distal half of rostrum dorsally unarmed 18
18. Second abdominal somite not dorsally carinate (See: Kemp, 1906, p. 21) . . . . *A. pulchra* A. Milne Edwards, 1890.*
Second abdominal somite dorsally carinate (See: Balss, 1925, p. 258) . . . . *A. eximea* Smith, 1884.
(=*A. brachytelsonis* Bate, 1888; *A. edwardsi* Bate, 1888; *A. angusta* Bate, 1888)
19. Integument firm and pubescent (See: Balss, 1925, p. 259) . . . . *A. kempi* Balss, 1925.*
Integument thin and membranous (See: de Man, 1920, p. 69) . . . . *A. sibogae* de Man, 1916.

Genus 2. NOTOSTOMUS A. Milne Edwards, 1881.

KEY TO THE SPECIES OF NOTOSTOMUS

1. First two abdominal somites not dorsally carinate; dorsal carina of

carapace not denticulate on posterior two-thirds of its length; only one complete longitudinal carina on carapace........................2

All abdominal somites dorsally carinate; dorsal carina of carapace denticulate for practically its entire length; two or more complete longitudinal carinae on lateral surface of carapace....................3

2. Integument soft but firm; sixth abdominal somite more than twice as long as fifth (See: Balss, 1925, p. 267)........*N. vescus* Smith, 1886. (=*Acanthephyra brevirostris* Bate, 1888; *Acanthephyra batei* Faxon, 1895; *Notostomus batei* Balss, 1925)

Integument extremely thin and fragile; sixth abdominal somite once and a half as long as fifth (See: Balss, 1925, p. 266)..*N. mollis* (Smith, 1882) (=*Meningodora mollis* Smith, 1882; *Hymenodora mollis* Bate, 1888; *Notostomus fragilis* Faxon, 1895)

3. No semi-carina on posterior half of lateral surface of carapace immediately below the post-orbital....................................4

A semi-carina on posterior half of lateral surface of carapace immediately below the post-orbital....................................5

4. Only two longitudinal carinae on lateral surface of carapace (See: Bate, 1888, p. 829)............................*N. murrayi* Bate, 1888.*

Three longitudinal carinae on lateral surface of carapace (See: A. Milne Edwards, 1881, p. 7)........*N. gibbosus* A. Milne Edwards, 1881.*

5. Four longitudinal carinae on posterior half of lateral surface of carapace 6

Five longitudinal carinae on posterior half of lateral surface of carapace; a median lateral carina at base of rostrum......................9

6. A median lateral carina at base of rostrum (See: A. Milne Edwards, 1881, p. 8)...................*N. elegans* A. Milne Edwards, 1881.*

No median lateral carina at base of rostrum.......................7

7. Carina along lower margin of rostrum continuous with post-orbital (See: Balss, 1925, p. 268)......................*N. perlatus* Bate, 1888. (=*N. brevirostris* Bate, 1888)

Carina along lower margin of rostrum not continuous with post-orbital..8

8. Post-orbital and post-antennal carinae nearly parallel (See: Bate, 1888, p. 830)...........................*N. japonicus* Bate, 1888.*

Post-orbital and post-antennal carinae sharply divergent behind hepatic region (See: Smith, 1886 p. 676)...........*N. robustus* Smith, 1885. (=*N. beebei* Boone, 1930)

9. Dorsal carina of carapace straight along central portion and not very high (See: Balss, 1925, p. 269)................*N. westergreni* Faxon, 1893.

Dorsal carina of carapace very high and arched....................10

10. Rostrum not reaching end of antennal scale (See: Bate, 1888, p. 826) ....*N. patentissimus* Bate, 1888.*

Rostrum reaching considerably beyond end of antennal scale (See: Balss, 1925, p. 268)........................*N. longirostris* Bate, 1888. (=*N. atlanticus* Lenz, 1914)

Genus 3. EPHYRINA Smith, 1885.

Ephyrina benedicti Smith, 1885 (See: Balss, 1925, p. 269)
(=*Tropiocaris planipes* Bate, 1888; *Ephyrina hoskyni* Wood-Mason, 1891; *Ephyrina bifida* Stephensen, 1923)

Genus 4. HYMENODORA G. O. Sars, 1877.

KEY TO THE SPECIES OF HYMENODORA

1. Integument smooth, soft and membranous; rostrum not reaching beyond tips of eyes in adults (See: Balss, 1925, p. 270) .... *H. glacialis* (Buchholz, 1874)
(=*Pasiphae glacialis* Buchholz, 1874; *Hymenodora gracilis* Smith, 1886; *H. glauca* Bate, 1888; *H. mollicutis* Bate, 1888)
Integument rugose, soft but not particularly membranous; rostrum exceeding eyes in length and reaching to end of antennular peduncle in adults (See: Rathbun, 1904, p. 28)...... *H. frontalis* Rathbun, 1902.

Genus 5. SYSTELLASPIS Bate, 1888.

KEY TO THE SPECIES OF SYSTELLASPIS

1. Abdomen not dorsally carinate on any somite; rostrum about one-third as long as carapace (See: Balss, 1925, p. 245)..*S. braueri* (Balss, 1914)
(=? *S. echinurus* Coutière, 1911; *Acanthephyra braueri* Balss, 1914; *S. densispina* Stephensen, 1923)
Abdomen carinate on third and fourth somites; rostrum more than half as long as carapace..2
2. Hind margins of fourth and fifth abdominal somites crenate on either side of the median spine (See: Balss, 1925, p. 242)............ *S. debilis* (A. Milne Edwards, 1881)
(=*Acanthephyra debilis* A. Milne Edwards, 1881; *Miersia gracilis* Smith, 1882; *Acanthephyra debilis* var. *europoea* A. Milne Edwards, 1883; *Acanthephyra gracilis* Smith, 1886; *S. bouvieri* Coutière, 1905; *S. debilis* var. *indica* de Man, 1920)
Hind margins of fourth and fifth abdominal somites not crenate on either side of the median spine..3
3. A sharp longitudinal carina near lower margin of carapace (See: Balss, 1925, p. 244)........................... *S. cristata* (Faxon, 1893)
(=*Acanthephyra cristata* Faxon, 1893)
No sharp carina near lower margin of carapace......................4
4. Sixth abdominal somite and anterior portion of telson smoothly rounded dorsally (See: Faxon, 1896, p. 162).......... *S. affinis* (Faxon, 1896)
(=*Acanthephyra affinis* Faxon, 1896)
Sixth abdominal somite and telson deeply grooved along dorsal midline (See: Bate, 1888, p. 758)................ *S. lanceocaudata* Bate, 1888.

Genus 6. OPLOPHORUS A. Milne Edwards, 1837.

KEY TO THE SPECIES OF OPLOPHORUS

1. Second, third, and fourth abdominal somites terminating in a long spine; no spine at postero-lateral angle of carapace (See: A. Milne Edwards, 1883, Pl. 30)................*O. spinicauda* A. Milne Edwards, 1883.
 (=*O. foliaceus* Rathbun, 1906; *Hoplophorus foliaceus* Kemp, 1913; *Acanthephyra anomala* Boone, 1927)
 Third, fourth and fifth abdominal somites terminating in a long spine...2
2. No spine at postero-lateral angle of carapace.....................3
 A distinct spine at postero-lateral angle of carapace; outer margin of antennal scale spinose.......................................4
3. A distinct barb on inner margin of antennal scale near the tip; outer margin of same spinose (See: Balss, 1925, p. 249)...*O. grimaldii* Coutière, 1905.
 (=*Hoplophorus grimaldii* Courtière, 1905; ? *Acanthephyra pellucida* A. Milne Edwards, ms. fide Perrier. See Kemp, p. 66, 1906)
 No barb on inner margin of antennal scale; outer margin of same devoid of spines (See: de Man, 1931, p. 369)...*O. novae-zeelandiae* de Man, 1931.*
4. The median lateral carina at base of rostrum is subparallel to the dorsal margin; distal sixth of antennal scale unarmed; rostrum distinctly longer than antennal scale; small spine on lower margin of pleuron of first abdominal somite (See: Kemp, 1913, p. 63)..*O. gracilirostris* A. Milne Edwards, 1881.
 (=*O. longirostris* Bate, 1888; *Hoplophorus smithii* Wood-Mason, 1891; *Hoplophorus typus* (part) Balss, 1925)
 The median lateral carina at base of rostrum converges posteriorly toward the dorsal midline; distal fourth of antennal scale unarmed; rostrum rarely reaching beyond tip of antennal scale; no spine on lower margin of pleuron of first abdominal somite (See: Bate, 1888, p. 762)...................................*O. typus* H. Milne Edwards, 1837.
 (=*O. brevirostris* Bate, 1888)

Note: Since this paper was written, a specimen of *Bentheocaris stylorostratis* Bate has come to hand. It was collected with a closing net in 900 fathoms just west of the Gulf Stream off the coast of New Jersey on September 1, 1935 by the *Atlantis* of the Woods Hole Oceanographic Institution. This specimen is 57 mm. long, the largest of the five recorded specimens, and is apparently an adult female. An examination of the mouth-parts discloses that this species belongs in the genus *Acanthephyra* near *A. cucullata* Faxon. This same conclusion was reached previously by Dr. W. T. Calman and published in Union S. Africa Fish. Mar. Biol. Survey **4(3)**: 14. 1925.

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ZOOLOGY.—*Nomenclatorial changes involving California polychaete worms.*[1]

OLGA HARTMAN, University of California. (Communicated by MARY J. RATHBUN.)

In the course of a study of the marine annelid fauna of California certain revisions in the current names of a number of species appear necessary:

Cirriformia nom. nov. pro *Audouinia* Quatrefages, 1865, nec A. Costa. *Audouinia* was used by Costa in 1834 and 1851 for a genus of amphipods and is now considered a synonym of *Corophium* (cf. Stebbing, 1906, p. 685). Two common species from California are (1) *Cirriformia luxuriosa* (Moore, 1904) whose range is hereby extended northward to Dillon Beach, Marin County, California, and (2) *C. spirabrancha* (Moore, 1904) known from Mendocino County (Chamberlin, 1919) south to San Diego, California (Moore, 1904).

Eteone pacifica nom. nov. pro *E. maculata* Treadwell, 1922, nec OErsted, 1843. This species described from Friday Harbor (Treadwell), was collected by Mr. C. E. Moritz and the author in 1933 at Moss Beach, San Mateo County, California.

Stylarioides dimissus nom. nov. pro *S. minuta* Treadwell, 1914, nec *Pherusa minuta* Quatrefages, 1865, which is a *Stylarioides*. Originally described from La Jolla, California, this species is now known to range northward to Moss Beach, San Mateo County, California.

Changes necessitating a shift of generic name or reduction to synonymy follow. The synonyms in each case follow the signs of equality:

[1] Received October 3, 1935.

Aphrodita castanea Moore, 1910 = *A. californica* Essenberg, 1917
Aphrodita japonica Marenzeller, 1879 = *A. solitaria* Essenberg, 1917
Acholoe fragilis (Baird) = *Lepidonotus fragilis* Baird, 1863
Acholoe leioseta (Chamberlin) = *Halosydna leioseta* Chamberlin, 1919
Acholoe pulchra (Johnson) = *Polynoe pulchra* Johnson, 1897 = ?*Halosydna succiniseta* Hamilton, 1915
Lepidonotus lagunae (Hamilton) = *Halosydna lagunae* Hamilton, 1915
Nereis vexillosa Grube, 1851 = *Mastigonereis spinosa* Kinberg, 1866
Perinereis monterea (Chamberlin) = *Nereis* (*Neanthes*) *monterea* Chamberlin, 1918
Uncinereis agassizi (Ehlers), 1868 = *Nereis notomacula* Treadwell, 1914 = *Uncinereis subita* Chamberlin, 1919
Glycera alba (Müller), 1788 = *Glycera basibranchia* Chamberlin, 1919
Glycera branchiopoda Moore, 1911 = *Glycera profundi* Chamberlin, 1919
Glycera macrobranchia Moore, 1911 = *Glycera exigua* Chamberlin, 1919
Eumida longicornuta (Moore) = *Eulalia longicornuta* Moore, 1906
Arabella semimaculata (Moore), 1911 = *Arabella munda* Chamberlin, 1919
Lumbrinereis inflata (Moore), 1911 = *Lumbrinereis cervicalis* Treadwell, 1922 = *Lumbriconereis albifrons* Crossland, 1924
Ninoe chilensis Kinberg, 1865 = *Ninoe palmata* Moore, 1903
Orbinia nuda (Moore) = *Aricia nuda* Moore, 1911 (*Aricia* sensu Savigny, 1822, nec R. L., 1817, pro Lepidoptera)
Scoloplos acmeceps Chamberlin, 1919 = *S. elongata* Johnson, 1901, nec Quatrefages, 1865
Boccardia natrix (Söderström), 1920 = *Polydora californica* Treadwell, 1914 = nec *Spio californica* Fewkes, 1889
Laonice cirrata (M. Sars), 1851 = *Spionides foliata* Moore, 1923
Laonice sacculata (Moore) = *Spionides sacculata* Moore, 1923
Nerinides acuta (Treadwell) = *Spio acuta* Treadwell, 1914
Cirratulus cirratus (O. F. Müller) = *C. cingulatus* Johnson, 1901
Ophelia magna (Treadwell) = *Ophelina magna* Treadwell, 1914
Ophelia mucronata (Treadwell) = *Ophelina mucronata* Treadwell, 1914

ZOOLOGY.—*A new coyote from Honduras.*[1] E. A. GOLDMAN, Bureau of Biological Survey.

In Central America coyotes are restricted mainly to open savanna or semi-forested areas, subject to a long dry season, along the Pacific coast as far south as Costa Rica. They do not regularly occur in the unbroken forests that cover so much of the general region, and form more or less effective barriers limiting their distribution. The discovery by the veteran collector, Mr. C. F. Underwood, of an undescribed form in an open, sterile, rocky section on the Caribbean side

[1] Received October 16, 1935.

of the continental divide in central Honduras is, therefore, of considerable interest.

Canis hondurensis sp. nov.

Honduras Coyote

Type.—From Cerro Guiñote, northeast of Archaga, on the Talanga road north of Tegucigalpa, Honduras. No. 251447, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by C. F. Underwood, August 18, 1934. X-catalogue number 27352.

Distribution.—Known only from the open country near the type locality.

General characters.—A rather small, rufescent species, with coarse, thin pelage and a short, broad skull. Similar in color to *Canis latrans dickeyi*, of the Pacific coast region of Salvador, but smaller, and skull characters, especially the shorter tooth rows and more widely spreading zygomata, distinctive. Resembling *C. l. goldmani* of eastern Chiapas, Mexico, but back apparently more heavily overlaid with black and differing in various cranial features.

Color.—*Type:* Top of head and back coarsely grizzled buffy grayish mixed with black, the black tending to predominate on the back; muzzle, outer surfaces of ears, flanks, fore and hind limbs rusty rufous; a short, narrow line of black hairs along middle of anterior surface of forearm; under parts sparsely clothed, the hairs light buffy across abdomen, becoming whitish on throat and inguinal region; a few inconspicuously dark-tipped hairs across under side of neck; tail above overlaid with black like back, below light buffy, giving way to black all around at tip.

Skull.—Similar in general to that of *C. l. dickeyi* but smaller, especially shorter, with more widely spreading zygomata; nasals much shorter, and broader between maxillae; palate relatively broader; audital bullae smaller; dentition similar, but maxillary and mandibular tooth rows shorter, the premolars more closely crowded. Compared with that of *C. l. goldmani* the skull is somewhat smaller, but with similarly wide spreading zygomata; frontal region broader, but rather highly arched as in *goldmani;* nasals broader between maxillae; lambdoid crest normal, not strongly projecting and broadly rounded in outline as in *goldmani;* interpterygoid fossa broader posteriorly; bullae smaller, more flattened, less distended along inner sides below; maxillary and mandibular tooth rows shorter; premolars more closely crowded; lower carnassial rather large, high and trenchant.

Measurements.—*Type:* Total length, 1,240 mm.; tail vertebrae, 350; hind foot, 190. An adult female topotype: 1,130; 290; 190. *Skull* (type): Greatest length, 190.3; condylobasal length, 178.2; zygomatic breadth, 100.7; breadth of rostrum (at constriction between first and second upper premolars), 30; interorbital breadth, 35.1; postorbital constriction, 39.1; breadth across mastoid processes of squamosal, 60.7; greatest length of nasals, 76; width of nasals (across middle between maxillae), 12.6; maxillary tooth row (alveoli), 77.2; crown length (outer side) of upper carnassial, 20; crown width of upper carnassial, 9.9. An adult female topotype: Greatest length, 181.5; condylobasal length, 171.9; zygomatic breadth, 107.7; breadth of rostrum, 31.4; interorbital breadth, 35; postorbital constriction, 37; breadth across mastoid processes of squamossal, 62.9; greatest length of nasals, 68.2; width of nasals, 11.4; maxillary tooth row, 74.7; crown length of upper carnassial, 19; crown width of upper carnassial, 9.7.

Remarks.—It is probable that *Canis hondurensis* will eventually require reduction to subspecific status under the widely ranging *Canis latrans*, but

in the absence of evidence of intergradation, and in view of the possibility of complete geographic isolation it seems best, meanwhile, to treat the animal as a full species.

Mr. Underwood describes the region of the type locality as open, sterile and rocky, and concerning the occurrence and habits of coyotes says: "They seem to prefer to make their dens amongst the rocks often within a league or so from cattle farms or haciendas where calves and chickens can be got. The natives resort to poison when they become too numerous. In several other parts of the country where conditions are analogous to the place where these were taken they are more or less abundant. They are very wary and difficult to shoot, but at times fall at night light hunting."

Specimens examined.—Three, all from the type locality.

ENTOMOLOGY.—*New neotropical empoascan leafhoppers.*[1] P. W. OMAN, Bureau of Entomology and Plant Quarantine. (Communicated by HAROLD MORRISON.)

This paper contains descriptions of 12 apparently new species of *Empoasca* from South America, Costa Rica, and Puerto Rico which the writer has encountered in the course of his work during the past few years. Since names have been requested for most of these it seems desirable to describe them at this time. Unless otherwise stated the illustrations accompanying these descriptions show a magnification of approximately 65 diameters.

Empoasca peregrina n. sp.

Resembling *trifasciata* (Gillette), but longer, with a black spot on apex of vertex and lacking dorsal spines. Length 4.75 mm.

External characters: General ground color pale yellowish-white. Apex of vertex with a round black spot. Posterior margin of pronotum, all of scutellum, and adjacent margins of elytra piceous to fuscous. Elytra hyaline, with a transverse smoky vitta across middle and another just before apical cross-veins, beyond cross-veins faintly smoky. Form generally more slender than that of *trifasciata.*

Male internal structures (Fig. 1, A): Lateral processes slender, in ventral view bluntly rounded apically. Dorsal spines rudimentary. Styles strongly diverging distally. Aedeagus comparatively slender, with a short projection on posterior margin. Sternal apodemes very large, rather slender and parallel sided, reaching beyond middle of 6th segment.

Described from a single specimen, the holotype male, intercepted at the Plant Quarantine inspection house at Washington, D. C., Jan. 8, 1934, in cotton lint packing from Peru. Type, Cat. No. 51283, U. S. N. M.

Empoasca rubraza n. sp.

Apparently resembling Osborn's species, *picta, decorata,* and *rubromaculata* in size and color but differing from them in color pattern, particularly in the two longitudinal red stripes on pronotum. Dorsal spines saber-shaped in lateral view. Length 3.1–3.3 mm.

[1] Received October 1, 1935.

External characters: Color bluish-green with contrasting red or orange-red marks. Face suffused with pale orange-red; vertex pale bluish-green with a pale orange dash next to each eye and a spot above each ocellus, these markings often irregular and poorly outlined. Pronotum with a bright orange-red stripe each side of median line, these slightly narrowed posteriorly. Elytra with elongate red stripes on each side of claval sutures, the claval stripe covering all but margins of clavus; costal submargin faintly orange tinged. Apical one-third of elytra subhyaline, veins pale and distinct. Vertex short, slightly produced medially; general form rather broad. Female genital segment impressed laterally about half way from base, posterior margin truncate or very slightly notched medially.

Male internal structures (Fig. 1, B–C): Lateral processes comparatively stout, apical portions sinuately curved, with tips directed caudad and inward. Dorsal spines broad in lateral view, slightly curved and sharply pointed; in general outline somewhat saber-shaped. Aedeagus short, portion for muscular attachment curved upward and then caudad; outline in lateral view very distinctive in the genus. Styles broadened before tips in ventral view; tips bent obliquely downward in lateral view. Sternal apodemes large, reaching beyond base of 5th segment.

Holotype male from Loreto, Prov. Missiones, Argentina, Nov. 29, 1931, A. A. Oglobin. Allotype female from the same locality, Dec. 6, 1931. Paratypes, 6 males and 13 females from the above locality and collector, taken on various dates from Nov. 25 to Dec. 10, 1931. There is also at hand 1 female from Huachi, Beni, Bolivia, September, W. M. Mann, Mulford Biological Exploration, 1921–22. Type, Cat. No. 51284, U. S. N. M.

Empoasca perelegans n. sp.

A large species with two black spots on vertex and with elytral stripes of smoky-fuscous, except apically. Length 3.5–4 mm.

External characters: General ground color pale bluish green; specimens collected late in the season (September) yellow to white. Face with a red stripe from below each ocellus to apex of clypeus, the two fused apically. Vertex with a pair of round black spots on anterior margin near median line and a transverse red stripe posteriorly. Pronotum faintly and irregularly marked with red each side of median line except posteriorly. Claval veins and claval sutures marked with smoky-fuscous; similar stripes between veins of corium before cross-veins; elytra hyaline except for smoky-fuscous stripes. Form rather slender, vertex slightly produced medially. Posterior margin of female genital segment produced and rounded, with a faint notch medially.

Male internal characters (Fig. 1, D): Lateral processes slender and tapered to sharp points. Dorsal spines stout, bifurcate apically. Aedeagus ending in a rounded, lobe-like process; below this a pair of slender, curved processes arising from posterior margin. Styles strongly diverging distally in ventral view. Sternal apodemes relatively broad, reaching to base of 5th segment.

Holotype male, allotype female, and 3 male and 27 female paratypes from San Pedro de Montes de Oca, Costa Rica, May 2, 1934, collected from *Annona cherimola* by C. H. Ballou. Other paratypes, 9 females and 1 male, collected by Mr. Ballou at the same locality Sept. 16, 1933, from *A. cherimola* and *A. muricata.* Type, Cat. No. 51285, U. S. N. M. Paratypes in collection of C. H. Ballou. There are also specimens at hand from La Ceiba, Honduras, and Vicosa, Minas Geraes, Brazil.

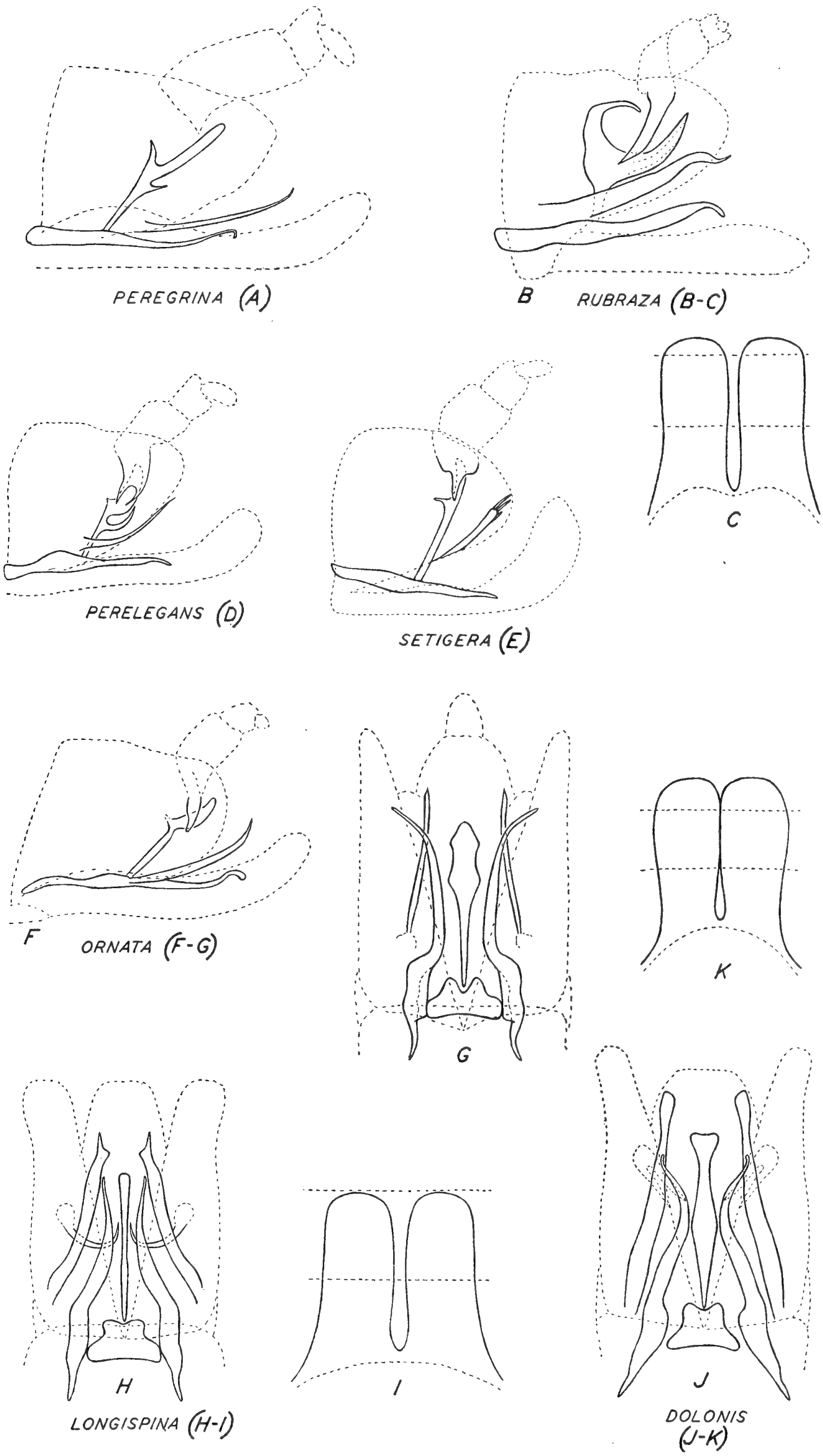

Fig. 1.—Internal structures of male. A, lateral view of genitalia of *Empoasca peregrina*. B, lateral view of genitalia; and C, sternal apodemes of *rubraza*. D, lateral view of genitalia of *perelegans*. E, lateral view of genitalia of *setigera*. F, lateral view; and G, ventral view, of genitalia of *ornata*. H, ventral view of genitalia; and I, sternal apodemes of *longispina*. J, ventral view of genitalia (×100); and K, sternal apodemes of *dolonis*.

Empoasca setigera n. sp.

A comparatively robust species with the lateral processes bearing stout spine-like setae apically and the dorsal spines short. Length 3.3 mm.

External characters: Vertex, pronotum, and scutellum greenish-yellow, marked with white areas, the most constant of which are a median dash on vertex, a transverse row of spots on pronotum anteriorly, and spots on disk of scutellum. Elytra hyaline with a green tinge. Species comparatively broad; vertex short, slightly produced medially. Female genital segment truncate posteriorly.

Male internal structures (Fig. 1, E): Lateral processes short, nearly straight, each bearing several short, stout, spine-like setae on apex and inner margin before apex. Dorsal spines broad basally, abruptly narrowing to short, slender spines. Aedeagus slender. Sternal apodemes rudimentary.

Holotype male from Loreto, Prov. Missiones, Argentina, Nov. 29, 1931, A. A. Ogloblin. Allotype female from the same locality and collector, Dec. 12, 1931. Paratypes, 50 males and 5 females from the above locality and collector, taken on various dates from Nov. 25 to Dec. 18, 1931. Type, Cat. No. 51286, U. S. N. M.

Empoasca ornata n. sp.

Pale green, marked with orange-red on head and thorax. More slender than *rubraza*, n.sp., and without the bluish coloration. Length 3.7 mm.

External characters· General ground color pale green. Face irregularly marked with orange-red; vertex with a transverse band of the same color, interrupted on median line. Pronotum and scutellum irregularly washed with orange-red. Elytra hyaline, faintly mottled with smoky brown areas especially along dorsum. Vertex slightly produced medially, form more slender than that of *rubraza.*

Male internal structures (Fig. 1, F–G): Lateral processes nearly straight, tips turned upward in lateral view. Dorsal spines blunt. Aedeagus relatively slender in lateral view, much broadened distally in ventral view. Styles strongly diverging posteriorly in ventral view; in lateral view apical portions twisted and tips somewhat knob-like. Sternal apodemes rudimentary.

Holotype male from near mouth of Rio Mapiri, Bolivia, September, Mulford Biological Exploration 1921–22. Type, Cat. No. 51287, U. S. N. M.

Empoasca longispina n. sp.

A large species without definite markings but with unusually long dorsal spines. Pygofer with several short spine-like setae on posterior margins. Length 4 mm.

External characters: Color golden green without definite markings but head and portions of thorax with a granular appearance. Apical one-third of elytra hyaline. Vertex short, very slightly produced medially.

Male internal structures (Fig. 1, H–I): Lateral processes sharply pointed, nearly straight in lateral view; in ventral view slightly bowed inward, with a blunt tooth on inner margins before tips. Dorsal spines slender and tapering to sharp points, unusually long and extending first downward and slightly cephalad and mesad, tips curved caudad and slightly upward. Aedeagus slender. Styles slender apically. Posterior margins of pygofer each with about 5 short spines which vary considerably in size and are directed mesad and caudad. Sternal apodemes reaching base of 5th segment.

The large size and lack of markings seem to make this species distinct

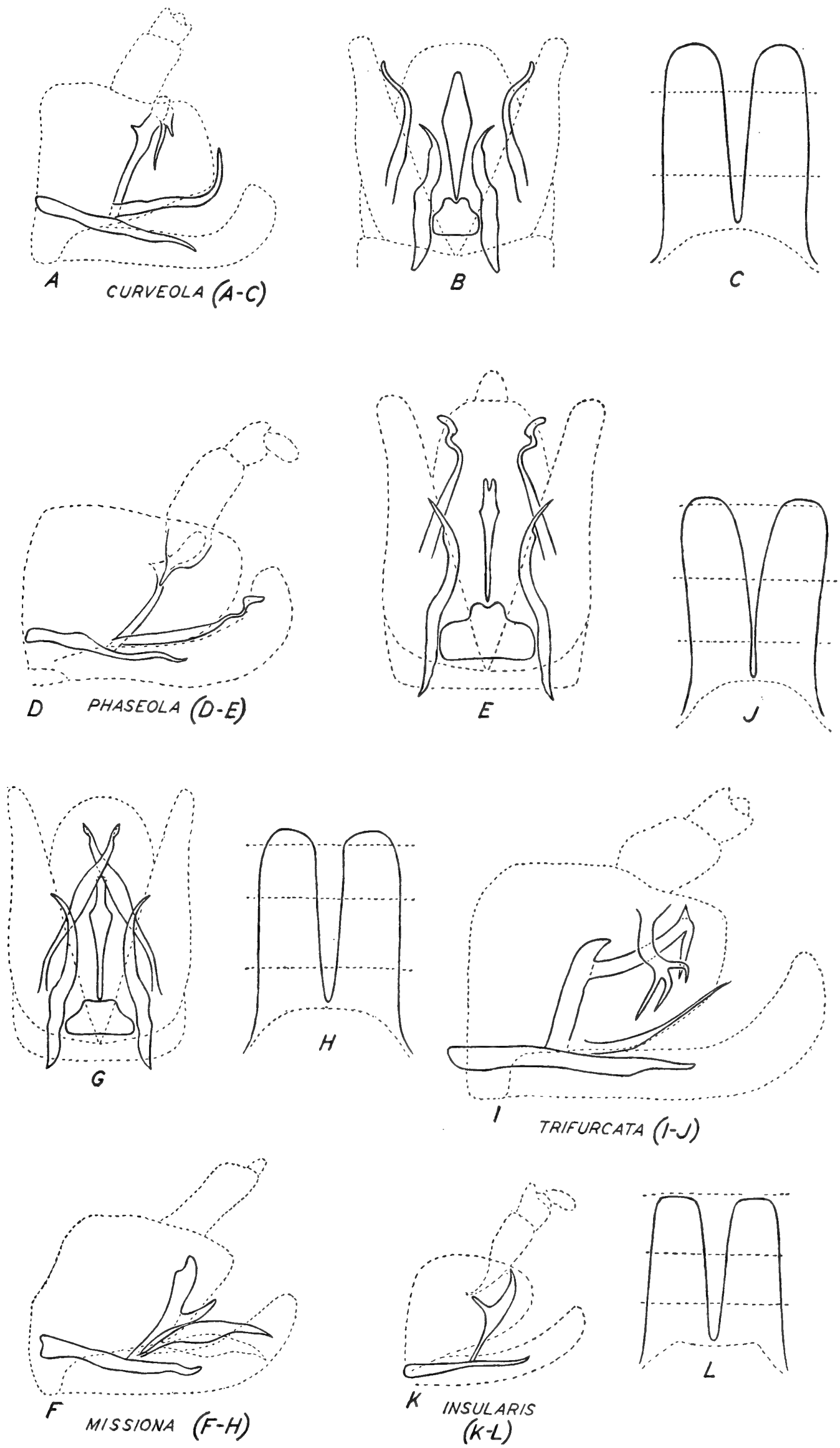

Fig. 2.—Internal structures of male. A, lateral view; and B, ventral view, of genitalia; and C, sternal apodemes of *Empoasca curveola.* D, lateral view; and E, ventral view, of genitalia of *phaseola.* F, lateral view; and G, ventral view, of genitalia; and H, sternal apodemes of *missiona.* I, lateral view of genitalia (×100); and J, sternal apodemes of *trifurcata.* K, lateral view of genitalia; and L, sternal apodemes of *insularis.*

from any of the South American forms described by Osborn. Structurally this species seems close to *salinarum* Berg,[2] but differs in coloration.

Holotype male from Loreto, Prov. Missiones, Argentina, Dec. 1, 1931, A. A. Ogloblin. Type, Cat. No. 51288, U. S. N. M.

Empoasca dolonis n. sp.

A slender species with forked dorsal spines and subtruncate lateral processes. Length 3–3.2 mm.

External characters: Color pale green to pale golden green. Ocelli circled with white. Pronotum and scutellum with white areas; elytra with a pale golden dash along claval sutures basally. Species slender, vertex well produced and rather narrow. Female genital segment truncate posteriorly.

Male internal structures (Fig. 1, J–K): Lateral processes extending caudad and slightly upward; apices flattened dorso-ventrally, in ventral view obliquely subtruncate, upper surfaces slightly concave before apices. Dorsal spines forked, but in lateral view appearing as single spines. Aedeagus broad apically in lateral view. Styles more slender apically than is usual in the genus, in lateral view bowed upward just before apices which are directed downward. Sternal apodemes large, extending to middle of 5th segment.

Holotype male from Loreto, Prov. Missiones, Argentina, Nov. 25, 1931, A. A. Ogloblin. Allotype female with the same data but collected Nov. 29, 1931. Paratypes, 4 males and 12 females from the above locality and collector, taken on various dates from Nov. 27 to Dec. 18, 1931. Type, Cat. No. 51289, U. S. N. M.

Empoasca phaseola n. sp.

A rather large, slender species without definite markings. Lateral processes sinuated apically and enlarged at tips. Length 4–4.25 mm.

External characters: Pale green to yellowish green with indefinite white areas on head and thorax. Elytra subhyaline before cross-veins, sometimes with faint golden stripes longitudinally; beyond cross-veins hyaline. Vertex well produced; general form comparatively slender. Posterior margin of female genital segment produced and rounded, with a faint notch medially.

Male internal structures (Fig. 2, D–E): Lateral processes relatively stout and straight basally, apically slender and strongly sinuated, apices enlarged and somewhat foot-shaped. Dorsal spines broad basally, abruptly tapered and ending in a slender finger-like process. Aedeagus simple, relatively slender. Sternal apodemes close together, reaching nearly to base of 5th segment, apices obliquely subtruncate.

Holotype male, allotype female, and 3 male and 30 female paratypes from San Pedro de Montes de Oca, Costa Rica, Oct. 21, 1933, collected from *Phaseolus vulgaris* by C. H. Ballou. Type, Cat. No. 51290, U. S. N. M. Paratypes in collection of C. H. Ballou.

Empoasca trifurcata n. sp.

Indistinguishable externally from small examples of *fabae* (Harris), but with the lateral processes straight and slender and the dorsal spines trifurcate. Length 3 mm.

External characters: Color pale green; head and thorax marked with the usual yellowish and white areas. Vertex slightly produced medially.

Male internal structures (Fig. 2, I–J): Lateral processes extending caudad

[2] *Hemiptera Argentina,* p. 274. 1879.

and slightly upward, gradually tapering from bases to slender, sharp-pointed apices. Dorsal spines stout, each terminating in three slender, pointed processes, of which the posterior two are bent. Aedeagus stout, extending upward, then obliquely upward and backward, and terminating in a finger-like spine which extends downward and slightly to the right. Sternal apodemes very long, reaching base of 6th segment; apices bluntly rounded.

Holotype male from Loreto, Prov. Missiones, Argentina, Nov. 29, 1931, A. A. Ogloblin. Paratype, 1 male with the same data, but collected Dec. 14, 1931. Type, Cat. No. 51291, U. S. N. M.

Empoasca curveola n. sp.

Externally indistinguishable from *trifurcata*, n. sp., but with the lateral processes strongly curved and comparatively stout. Length 3 mm.

Male internal structures (Fig. 2, A–C): Lateral processes of nearly uniform width throughout, slightly stouter basally and bluntly pointed apically, in lateral view with apical one-third bent upward, in ventral view apical one-half curved obliquely outward but with extreme tips bent caudad. Dorsal spines forked basally, each with a short, sharp spine from inner margin and a longer, slender spine directed downward and curved slightly inward. Aedeagus slightly broadened apically in lateral view, margins sinuately curved. Sternal apodemes reaching middle of 5th segment, tapering slightly from bases to apices, apices rounded.

Holotype male and 2 male paratypes from Caseros, Prov. Buenos Aires, Feb. 3, 1927, C. F. Henderson. Other paratypes, 2 males collected by Mr. Henderson at Las Heras, Prov. San Juan, Dec. 10, 1926. Type, Cat. No. 51292, U. S. N. M.

Empoasca missiona n. sp.

Externally indistinguishable from *trifurcata* but with the lateral processes swollen at middle and the dorsal spines obsolete. Length 3 mm.

Male internal structures (Fig. 2, F–H): Lateral processes slender basally, gradually becoming stouter to middle and tapering to apices, which are pointed in lateral view, but constricted on inner margins and obliquely truncate in ventral view. Dorsal spines rudimentary. Aedeagus in lateral view with a curved extension from posterior margin, this consisting of two thin structures which can be seen to diverge apically when viewed from caudal aspect. Sternal apodemes reaching nearly to middle of 6th segment.

Holotype male from Loreto, Prov. Missiones, Argentina, Dec. 14, 1931, A. A. Ogloblin. Type, Cat. No. 51293, U. S. N. M.

Empoasca insularis n. sp.

Superficially identical with *trifurcata*, but slightly smaller and without distinct dorsal spines or lateral processes. Female genital segment with posterior margin slightly produced and rounded, faintly notched medially. Length 2.5–2.75 mm.

Male internal structures (Fig. 2, K–L): Lateral processes and dorsal spines rudimentary. Aedeagus simple but relatively stout. Styles slightly turned upward apically in lateral view, in ventral view diverging posteriorly. Sternal apodemes unusually large, reaching to base of 6th segment.

Holotype male, allotype female, and 6 male and 4 female paratypes from Rio Piedras, Puerto Rico, May 20, 1932, collected by M. D. Leonard on *Annona* (spelled *Anonia*) *diversifolia*. Type, Cat. No. 51294, U. S. N. M.

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JOURNAL
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VOL. 26 FEBRUARY 15, 1936 No. 2

BOTANY.—*Certain Cactaceae of Venezuela: New and old species of* Opuntia *and* Melocactus.[1] H. PITTIER, Caracas, Venezuela.

In the course of my botanical work in Venezuela, I have become closely acquainted with some of the Cactaceae which form one of the main elements of the thorn-bushes of this country. Besides, I have now in cultivation and under observation a few doubtful species. The following are the first results of my investigations.

Opuntia metuenda Pittier, sp. nov. (Cylindropuntiae-Leptocaules)

Horrida, insolite armata, trunco ramisque lignosis, teretibus, decumbentibus vel interdum suberectis; areolis parvis cano-villosis, parce vel haud glochidiatis, aculeis 1–3, nudis, porrectis, flavescentibus, uno longiore, armatis; articulis teretibus, dissitis, plus minusve alternis, caducissimis; foliis parvis, crassis, obovoideis, acuminatis, cito caducis; areolis articuli cujusque 22–28, 3–4 inferioribus inermibus aculeatisve vel setis rigidis rubescentibus instructis, reliquiis superioribus 1-aculeatis, aculeo nudo, longo, aciculari, flavescenti, interdum aliisque 1–2 obsoletis adjectis; glochidiis inconspicuis vel nullis; floribus parvis, luteis; ovario obovato, areolis paucis, glochidiatis vel raro apicem versus 1–2 aculeis instructo; perianthio plus minusve rotato, segmentis exterioribus brevibus latisque, minute apiculatis, interioribus obovato-spathulatis, basi angustis, apice obtusis subacuminatisve; staminibus numerosis, flavescentibus, filamentis tenuibus, antheris oblongo-linearibus basifixis; stylo flavo, crasso, apicem versus attenuato; stigmate magno, purpureo, 6–8-lobulato; bacca obovoideo-globosa, matura rubra, areolis fere inermibus, glochidiatis, interdum armatis.

Caudices 40–120 cm. longi, 1.2–1.5 cm. diam.; articuli 4–6 cm. longi, 0.8–1 cm. diam. Aculei 1.5–4 cm. longi. Folia 3 mm. longa. Flores plus minusve 3 cm. longi, 1.5–2 cm. diam. Petala interiora 1.5–1.7 cm. longa, 1–1.5 cm. lata. Stamina plus minusve 1.5 cm. longa. Stylus (cum stigmate 3–4 mm. longo) 1.5 cm. longus. Bacca 1–1.2 cm. diam.

LARA: Savannas around Barquisimeto, June 28, 1913 (*Pittier* 6415); Barquisimeto, in ravines descending to Rio Turbio, flowers and fruits, September 18, 1923 (*Pittier* 11176, type). The above description was drawn (flower and fruit) from this latter specimen and partly from living plants in my garden obligingly sent from Barquisimeto by Brother Nectario of the La Salle College, to whom I extend my best thanks. From recent information it appears that the species is far from being restricted to the vicinity of Barquisimeto. Dr. A. Jahn reports it as growing abundantly in the hills

[1] Received October 24, 1935.

that surround Lagunillas (Mérida), at an altitude of about 1000 to 1200 meters. It is also said to be common in arid places through the State of Falcón and in eastern Venezuela around Cumaná (Sucre). Thus, the altitudinal range of the species would be from sea level to about 1200 meters.

Opuntia metuenda is known locally as *guasabar, guasábara, tuna de guasábara* (Lara), *guasábana* (Sucre).

Opuntia bisetosa Pittier, sp. nov. (Platyopuntiae-Elatiores)

Planta elata, e basi ramosa; articulis ovato-oblongis obovatisve, crassiusculis, pallide viridibus; areolis fere 7-seriatis, 6 vel 7 in quaquam serie[2] (marginalibus exceptis); aculeis areolarum juvenilium 5 vel minus, primum lutescentibus demum albidis; aculeis areolarum maturarum 8–10, robustis, albidis, 1 centrali, erecto, longiore, compresso, distorto, 7–9 brevioribus, acicularibus, plus minusve obliquis, inferioribus pluries setis 2, longis, rigidis, suffultis; foliis tenuibus, elongatis, subteretibus, subtiliter apiculatis, apice purpurascentibus; floribus modice magnis; ovario obconico, areolis 8-seriatis, 5 quaquam serie, inferioribus glochidiatis setaceisque, superioribus 1–3-aculeatis, albo-glochidiatis, aculeis albis, pilis brevibus rufescentibus cinctis, basi foliis 1–2 deciduis suffultis; foliis marginalibus 5, brevissimis, crassiusculis, apice spinulosis; perianthio cupuliformi, segmentis exterioribus late obovatis truncato-apiculatis, interioribus obovatis, apice rotundatis emarginatisve, basi virescentibus, apice incarnatis; staminibus numerosis, filamentis pallide roseis, antheris minutis, albis; stylo crasso, apicem versus leviter attenuato, albo; stigmate magno, subgloboso, pallide viridi, 8-lobulato; bacca ovata, omnino saturate rosea, superne aculeata, aculeis tenuibus brevibusque; seminibus albis.

Planta, ut videtur, usque ad 1.2 m. alta. Articuli usque ad 36 cm. longi, 18 cm. lati. Areolae 3–4 cm. remotae. Aculeus centralis usque ad 5 cm. longus. Folia 4–5 mm. longa. Flores 6.5 cm. longi, 5 cm. diam.; folia marginalia 5–6 mm. longa; perianthi segmenta interiora 2.8 cm. longa, 1.8 cm. lata; stamina circa 1.8 cm. longa; stylus 2–3 cm. longus; stigma 5–7 mm. diam. Bacca 5 cm. longa, 2.2 cm. diam., aculeis tenuibus usque ad 11 mm.

This description was drawn from a living plant obtained from a joint collected at Sanare, State of Lara, by Mr. Fr. Tamayo and cultivated in my garden. The species seems to be allied to *Opuntia wentiana* Britt. & Rose, from which it is easily distinguished by the two bristles at the base of the inferior spines in the areoles of the joints. Botanical specimens distributed under *Pittier* 13578 (type).

Opuntia wentiana Britt. & Rose, Cact. **1**: 116. 1919

Plant erect, much branched; joints ovate, obovate or elliptic, thickish, whitish green and covered in age with tiny white dots which give them a glaucous appearance; areoles 4 to each oblique row (marginal not included); spines on young joints mostly 3, later 4 to 6, to each areole, strong, terete, at first yellowish, turning to light gray; leaves early deciduous, thick, rounded, the apex spinulous, more or less purplish; flowers medium-sized; ovary obconical with 5 oblique rows of areoles, these 4 to the row and leav-

[2] According to my experience with the Venezuelan *Platyopuntiae*, the seriate disposition of the areoles on each face of the joint and the number of areoles in each row are fairly constant and constitute a good specific character. The same can be said of the leaves on the upper margin of the ovary.

ing the base of the ovary smooth and spineless; areoles spineless or with 1 minute spine, with a central tuft of white glochids surrounded by a narrow cushion of brown cellular hairs; at the base of the areole a short, thick, apiculate leaf; calycinal leaves 5–6; segments of the perianth broadly obovate, the outer ones shorter, more or less greenish, minutely apiculate, the inner ones larger, yellow, often tinged with pink near the apex, slightly emarginate; stamens numerous, the upper part of the filaments and the anthers pale pink; style whitish, its base thick, rounded, pointed at the base and attenuate towards the apex; stigma lobes 5–6, parted, cream colored, forming a subglobose head; fruit rather small, rounded at base, spineless but glochidiate, the umbilic very deep.

Joints 20–25 cm. long, 12–13 cm. broad. Leaves 3–5 mm. long. Distance between areoles in row 4–5 cm. Major spine up to 7 cm. long (on the average 4–5 cm.). Flowers 6 cm. long, 6 cm. diam. when fully open. Calycinal leaves 2 mm. long. Inner segments of perianth 3 cm. long, 2.5 cm. broad. Stamens 1.8–2 cm. long. Style (including stigma head 7 mm.) 2.7 cm. long. Fruit about 3 cm. long, 2.2 cm. diam.

But for the leaves, which are not subulate, and the inner segments of the perianth, of a darker yellow (turning to pink in age) and not acute, the above described plant agrees with the incomplete description of *Opuntia wentiana* as given by Britton and Rose and should at all events be keyed in the same group, which includes *O. caracasana*, *O. wentiana* and the new *O. bisetosa.* From the first one, the flowers and fruits of which are not known, it differs in the habit, the larger joints, the thick, turgid leaves and the spines, longer and mostly more numerous.

The above description was made from living specimens in my garden, obtained from a joint brought from El Tocuyo, State of Lara, by Mr. Fr. Tamayo. Herbarium specimens are being distributed under *Pittier* 13577.

Melocactus amoenus (Hoffmannsegg) Pfeiffer, Enum. Cact. 43. 1837

Melocactus caesius Wendland in Miquel, Nov. Act. Nat. Cur. 18, Suppl. 1: 184. 1841.

Melocactus griseus Wendland, l. c., p. 185.

Cactus amoenus Hoffmannsegg, in Preiss, Verzeich. ed. 7, 22. 1833.

In their standard work on Cactaceae, Britton and Rose give brief descriptions, under the names *Cactus amoenus* and *C. caesius*, of two supposedly distinct species of *Melocactus*, the first growing on the northern coast of Colombia, the other on the coast of Colombia and Venezuela. A mere comparison of the meager descriptions of these two species would incline one to the belief that they are identical. The given differentiating character "spines curved" and "spines straight" is too vague and inconstant, since perfect specimens of the Venezuelan *M. caesius* have always more or less curved spines.

Britton and Rose give Colombia as the type locality of *Melocactus amoenus* but in the second edition of Förster's *Handbuch der Kacteenkunde* we read[3]

[3] Carl Friedrich Förster's *Handbuch der Kacteenkunde in ihrem ganzen Umfange,* . . . von Theodor Rümpler. Zweite ganzlich umgearbeitete Auflage, pp. 425–426. 1886.

[translated]: "Fatherland Venezuela, where *Ed. Otto* found it up to an altitude of 1600 m. in the vicinity of La Guaira, growing on a red clayey soil among *Agave*, large columnar *Cerei* and *Opuntiae*. It existed there in considerable numbers and in all possible forms and sizes." Continuing, the *Handbuch* gives a description of the plant, which is wanting only in the characters of the fruit and seeds, and which applies accurately to most of the specimens I have handled: "Body conical-depressed, at first globose-depressed, grayish green. Ribs 10–12 [10–15] obtuse, not very salient; areoles white [to gray], [2.5 cm.] distant, sunken, but at first roundish; spines straightish, stiff, subulate, spreading, at first reddish, later dark brown; radial spines 8, the upper ones [usually shorter, 1 cm. and up] very short, the inferior ones very long [up to 3 cm.]; central spine solitary, erect, almost always absent on young individuals. Cephalium vaulted, whitish [with red bristles and spines]. Flowers in July, [1.7 to] 2.5 cm. in diameter when fully open, which happens in the afternoon only, the segments of the perianth pinkish red, long-lineal, spreading. [Fruit about 3 cm. long, obclavate, red]. One of the prettiest and most freely blooming species. Reaches a height of 15 to 18 cm., with a diameter slightly larger. The extirpation of the cephalium results sometimes in the production of new buds."

The additions between [ ] are mine and complete the description.

Further on we have a description of *Melocactus caesius*, which has 10 ribs, instead of 10 to 12, on a globose-depressed body, the areoles grayish, 2.5 cm. distant, the spines strong, stiff, straightish, pale reddish, the radial ones 8, spreading, the central one shorter. The flowers completely developed measure 15 to 18 mm. in diameter, the pinkish red segments of the perianth are lineal, and obtuse or emarginate at the apex, the stamens and the 7 lobes of the stigma yellow.

According to these descriptions, much more accurate than the ones of Rose and Britton, the two species would differ in the shape of the adult body, the number of the ribs, the color of the areoles, the length of the central spines and the diameter of the flowers, all characters very variable in any species. Moreover the *Handbuch*, after describing a variety *griseus* of *M. caesius*, with 15 ribs, adds that in all probability *M. caesius* and *M. griseus* are only forms of *M. amoenus*.

My own observations fully confirm this last view. In a single station, in a group of a large number of individuals of the same ancestry, all the types included under the descriptions of *M. amoenus*, *M. caesius* and *M. griseus* were represented. The form of the body is far from constant, the number of ribs varies from 10 to 15, the color of the areoles is either gray or white, the spines are seldom straight, the radial ones almost always 8 and of variable length. The color of the flowers is almost uniform but their size is reduced in the poorer forms, in which also the spines do not attain their full development.

For these reasons, I think that *Melocactus caesius* and *M. griseus* should be considered as synonymous with *M. amoenus*, which is the oldest name. It is even doubtful whether the forms described under the two first names ought to be considered as fixed varieties.

The type of *M. amoenus* was probably from the vicinity of La Guaira, Venezuela, and not from Colombia. The original description dates from 1833, that is from a time when the secession of Venezuela from Great Colombia in 1830 had hardly become generally known. There is no mention of any botanist or collector having visited the arid parts of the coast of Colombia in the few years previous to the first publication of the species, while in Caracas several persons, stimulated by the example of the illustrious Vargas, were interested in the flora of the surrounding region and may have sent to Europe samples of such striking plants as the one in question.

Melocactus amoenus appears almost everywhere in the arid parts of the coast of northern South America, including the islands, between Trinidad and Santa Marta. It is very doubtful whether the specimens photographed by Dr. Stahel in the interior of Dutch Guiana belong here. The cephalium of these plants, as it appears in the picture published in Britton and Rose (Cactaceae **3:** 234) is much larger and more prominent than in our species. I also think that the upper altitude of 1600 m. cited in the translation from Förster's *Handbuch* is exaggerated. To my knowledge, the species does not appear above 1000 m. and reaches its fullest development in the warmest stations, not far distant from the seashore. The plant also appears scattered in the semi-desert districts around Barquisimeto, El Tocuyo and Carora, in the State of Lara.

PALEOBOTANY.—*Field identification of the fossil ferns called* Tempskya.[1] ROLAND W. BROWN, U. S. Geological Survey.

Tempskya is a genus of fossil ferns whose remains, so far as now known and understood, are found in place exclusively in strata of Cretaceous age. Unlike the attractive black impressions of the fronds of Carboniferous ferns and seed-ferns commonly illustrated in textbooks and exhibited in museums, specimens of *Tempskya* are rough, irregularly cylindrical or conical blocks (Fig. 5) resembling some occurrences of fossil wood. The foliage of ferns, it may be noted, has been found in the same or contemporaneous strata as the *Tempskya* trunks, but the two have never been found in direct connection and consequently, no definite correlation between foliage and stems has yet been made. Because *Tempskya* has considerable value as a

[1] Published by permission of the Director, U. S. Geological Survey. Received October 19, 1935. Helpful suggestions in the preparation of this paper are acknowledged to my colleague, Charles B. Read.

stratigraphic indicator, and because collections made in the past few years have revealed the fact of its occurrence at numerous Cretaceous localities in the western United States, it is deemed appropriate now to emphasize the importance of looking for and collecting specimens of this genus, and, as an aid to the collector, to show how *Tempskya* may be recognized in the field and distinguished from other fossil plant materials with which it might be confused.

The first American specimens of *Tempskya* to be described were collected from the Patapsco (Lower Cretaceous) formation exposed in the valleys of Stony Run and Deep Run, north of Severn, Anne Arundel County, Maryland, and were named *T. whitei* by E. W. Berry (1) in honor of Dr. David White, of the U. S. Geological Survey. Although the cell structure in these specimens is silicified, it is poorly preserved, but enough is present to substantiate clearly the reference to the genus, which was first defined from European material. The original European tempskyas came from a number of horizons and localities. The first to be described were from Wealden (Lower Cretaceous) deposits in Tilgate Forest and the beach near Ecclesbourne, Sussex, England. They were called "arborescent ferns," and later, *Endogenites erosa*, implying affinity with monocotyledons, possibly palms. The name *Tempskya*, in honor of Friedrich Tempsky, the discoverer of several specimens in gravels along the River Elbe, east of Neupaka in Bohemia, Czechoslovakia, was given by Corda (2), who described four species in 1845, making *T. pulchra* the nominal type of the genus. However, the first fairly complete generic characterization was published by Kidston and Gwynne-Vaughan (3) in 1911, for it was based upon an excellently preserved specimen, which they called *T. rossica*, collected from Tertiary gravels (most probably derived from the erosion of nearby Upper Cretaceous deposits) in the basin of the Karaganda River on the west flank of the Mugodjar Mountains, Russia. Tempskyas have also been recorded from the Wealden in northern France and near Hanover, Germany; and from the Perucer beds (Cenomanian, Upper Cretaceous) near Lana, 35 kilometers west of Prague, Czechoslovakia.

In 1908, A. C. Silberling, of Progress, Mont., found a specimen of *Tempskya*, 33.5 cm. long, in sediments then thought to be of Kootenai (Lower Cretaceous) age, but now known to be of lower Colorado (Upper Cretaceous) age, in the Musselshell Valley about 10 miles southeast of Harlowton, Mont. This well-preserved specimen was not described until 1924, when Dr. A. C. Seward (4), of Cambridge,

England, named it *T. knowltoni* in honor of Dr. F. H. Knowlton, of the U. S. Geological Survey.

C. H. Wegemann, of the U. S. Geological Survey, in 1910, collected a specimen from a sandstone in the Thermopolis shale (Upper Cretaceous), 25 feet below the Mowry shale, in sec. 28, T. 41 N., R. 81 W., near Kaycee, Wyo. Although it posseses a number of well-defined stems embedded in a groundmass of roots, this specimen was not recognized as *Tempskya*, but was reported as "rootlets" on page 64 of U. S. Geological Survey Bulletin 471, 1912.

In recent years during the course of field work various members of the U. S. Geological Survey have collected additional characteristic material in the Cretaceous terrains of Idaho, Wyoming, Utah, and Nevada. The Idaho specimens were collected by G. R. Mansfield, W. W. Rubey, and J. S. Williams, and were found at two horizons—the weathered uppermost beds of the Wayan formation, of Colorado age, in the Lanes Creek quadrangle to the southeast of Grays Lake; and an especially prolific locality in the Aspen shale, also of Colorado age, in sec. 19, T. 5 N., R. 44 E., of the Teton Basin. Most of the Wyoming specimens were collected by W. W. Rubey and J. S. Williams from the Aspen shale, in the northeast corner of the Afton quadrangle; but one water-worn specimen was found by the writer in a gravel terrace resting upon the Green River formation in the valley of Twin Creek, near Fossil. The only specimen from Utah was collected by Frank L. Hess, of the U. S. Bureau of Mines, from Upper Cretaceous deposits near the head of Pack Creek just west of Mount Peale in the La Sal Mountains. The Nevada specimens were found by W. W. Rubey and Eugene Callaghan in the lower part of the Overton fanglomerate about 6 miles southwest of Kaolin, Clark County.

The material in the recent collections makes it possible to differentiate several new species, but the description, illustration, and naming of these species, together with a precise statement of their stratigraphic implications, is reserved for more elaborate treatment than is possible here. As an illustration of the stratigraphic significance of *Tempskya*, however, it may be stated that the Nevada specimens collected by Rubey and Callaghan have served, in conjunction with other plant fossils, to demonstrate satisfactorily that the portion of the Overton fanglomerate containing them is Cretaceous in age, not Miocene (?) as now designated (5). Because the plant and animal fossils found in many continental sediments are, at best,

so fragmentary, scarce, and lacking in diagnostic features that, with the limitations of our present knowledge, they are of little value as stratigraphic indicators, it becomes a matter of some importance to search for and collect such outwardly unprepossessing objects as *Tempskya* trunks and other petrifactions, which have well-preserved internal structures and can be identified with certainty as belonging within a given geologic range.

The aspect of *Tempskya* specimens depends somewhat upon the characteristics of the formation from which they originate. In external color or tone they may differ considerably, according to the weathering they have undergone, but internally, when well-preserved, they are usually dark. In size they may be as small as the specimen illustrated in Figure 5, or they may be a foot in diameter and several feet long. Their shape is generally roughly cylindrical or conical, with a surface that is irregularly corrugated, ridged, or furrowed, small holes sometimes terminating the broken ends of the curved rounded ridges. The transverse surface (see top of Fig. 5), especially when wet, usually reveals a number of scattered, irregularly circular or lobed bodies, from 0.5 to 1 or more centimeters in diameter, enclosing minute horseshoe-shaped figures and surrounded by a groundmass of thousands of closely packed, small, circular or elliptic structures. The former are cross-sections of a dichotomously branched stem with leaf traces; and the latter are sections of adventitious roots, forming a mat or felt around the stems. The whole constitutes in effect a trunk, called a false stem, that has become silicified. The corrugations on the external surface are thus seen to be portions of roots. When sufficiently magnified the stems are seen to consist of a prominent ring of xylem (wood) surrounded by a cortex composed of large-celled, thin-walled parenchyma; and an outer zone of thick-walled sclerenchyma. The conspicuous features of the roots are their almost uniform size and the presence of large-celled xylem elements arranged in the form of a cross. In the older parts of *Tempskya* trunks, roots may sometimes be found invading the stems. It should be stated that not all *Tempskya* blocks show the presence of stems; some may represent the outer or lower portions of a large trunk and thus con-

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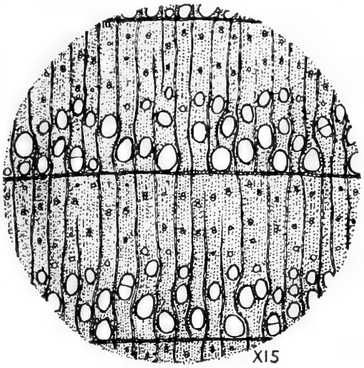
Fig. 1.—Transverse section of white ash, *Fraxinus americana.* Fig. 2.—Transverse section of western yellow pine, *Pinus ponderosa,* with three resin canals. Fig. 3.—A coal ball. Fig. 4.—Transverse section of *Psaronius gutbieri.* After Corda. Fig. 5.—*Tempskya knowltoni,* showing stems embedded in a groundmass of circular to elliptic adventitious roots. Fig. 6.—Piece of *Palmoxylon* sp. The fragment near the base, showing sections of two adventitious roots, is not a part of this trunk. All figures are somewhat diagrammatic and lack some details not considered necessary of delineation for the purposes of this paper.



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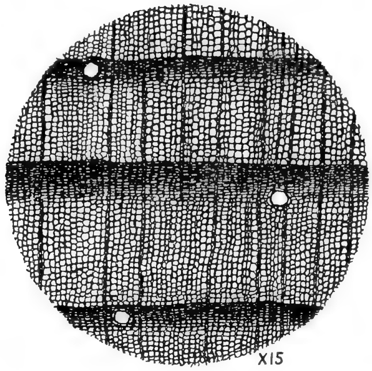

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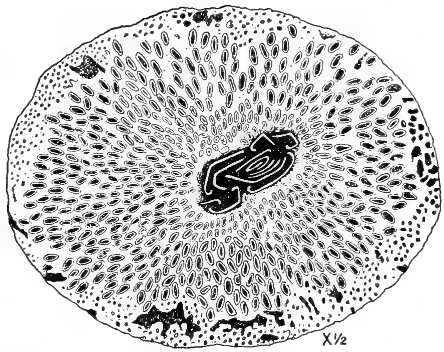

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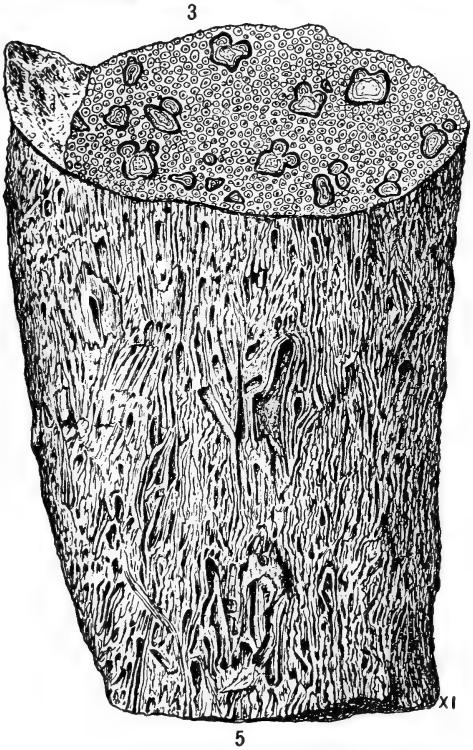

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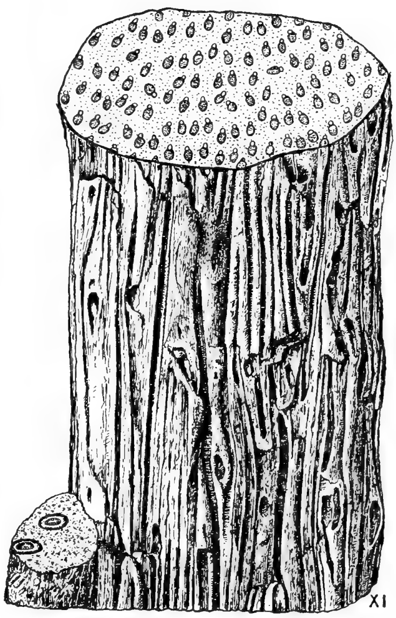

6

For explanation of Figs. 1–6, see bottom of opposite page.

sist only of a mass of roots. Such specimens are practically worthless so far as specific determination is concerned, but are valuable as indicating the presence of a *Tempskya* in the formation.

How may the tempskyas be distinguished in the field from other petrifactions of somewhat similar appearance? Excepting a few species of ferns, the confusion of *Tempskya* with the usual plant petrifactions encountered in the field is unnecessary if the collector is armed, as he invariably should be, with a hand lens of at least 10 to 14-power, and has learned a few elementary anatomical facts.

The common fossils that genetically and anatomically simulate *Tempskya* are specimens of a tree-fern genus, *Psaronius*, sometimes called "starling stones," found in upper Carboniferous and Permian strata. Figure 4 illustrates a transverse section of a *Psaronius*. It will be observed that the central portion of this section represents a single stem composed of a large number of concentrically arranged, arcuate vascular bundles, which, if viewed in longitudinal section, would present a system having a very complex pattern. Adventitious roots form a protective periphery around the stem. As a whole, this trunk, like that of *Tempskya*, could also be called a false stem.

Those irregular, rounded or angular nodules called coal balls (Fig. 3), found in strata of the Pennsylvanian and other periods, and unfortunately often overlooked and neglected by field geologists, may sometimes roughly resemble *Tempskya*. However, examination of them with a lens reveals that usually they are composed of a heterogeneous mixture of stems, leaves, roots, and other organs derived perhaps from as many different species of plants.

The plant petrifactions most commonly encountered in Mesozoic and Cenozoic formations are silicified or lignitized trunks of gymnosperms (cycads, ginkgos, conifers) and angiosperms (monocotyledons, dicotyledons). Of the gymnosperms the conifers are most frequent, but they will be least likely to be confused with *Tempskya*. A typical living conifer with which fossil conifers may be compared is the western yellow pine (*Pinus ponderosa*), of which Figure 2 is a transverse section revealing parts of four annual rings, the darker portion of the rings being late wood. This section consists of radially disposed wood elements (tracheids) of nearly uniform size, and resembles in appearance a wall constructed of small, hollow tiles. The darker color and apparently smaller size of the tracheids in the late growth of the annual ring is caused by the thickening of the cell walls. At irregular intervals the rows of tracheids are separated by thin, radial, pith rays; and, scattered sparsely among the tracheids, generally in or near the

late wood, are a few, large, circular openings, denoting resin canals. Such a section showing *tracheids and resin canals* is normally characteristic of the wood of that group of conifers which includes the pines, spruces, larches, and Douglas firs. Presenting sections similar to that of a pine, but *normally without resin canals,* is the other coniferous group that includes the true firs, hemlocks, sequoias, junipers, cedars, cypresses, and bald cypress.

Perhaps the petrifactions most likely to be confused with *Tempskya* are found among the monocotyledons, namely, fossil palm trunks or portions thereof. Figure 6 shows the weathered, ropy, external surface of a *Palmoxylon,* a transverse section of a portion of the stem, and some external material near the base, but not part of this stem, showing adventitious roots. The distinctive feature that separates *Palmoxylon* from *Tempskya* is the presence, as seen in cross-section, of numerous oval or bottle-shaped, more or less radially directed, fibrovascular bundles, consisting of a small vascular portion with several large vessels (xylem) and a larger, usually darker, fibrous portion composed of sclerenchyma. The transverse sections of the adventitious roots are normally larger than those in *Tempskya* and under low magnification have the appearance of two concentric circles. Specimens of *Palmoxylon* consisting of roots are most likely to be mistaken for *Tempskya* with stems, and those showing fibrovascular bundles for *Tempskya* with roots.

Contrasted with conifers and monocotyledons, the woody dicotyledons are distinguished by the presence of numerous relatively large vessels distributed conspicuously among the smaller elements. These vessels may be concentrated in the spring wood or beginning of the annual ring, as in the white ash (Fig. 1), or they may be spread rather evenly throughout the annual ring. The former are the *ring-porous woods* and include the oak, chestnut, sassafras, elm, mulberry, ash, locust, and catalpa. The latter are the *diffuse-porous woods* and include the walnut, hickory, birch, willow, poplar, sycamore, red gum, beech, cherry, maple, tulip tree, buckeye, and linden. A word of caution here is necessary to the effect that gradations between ring-porous and diffuse-porous woods are not uncommon and that the vessels of some species, such as the willows and poplars of the diffuse-porous group, are sometimes so numerous and small that even with a 14-power hand lens these species when poorly preserved as fossils may be mistaken for conifers.

It is regrettable that the study of fossil wood has not yet been as systematically and thoroughly organized as to be more generally

applicable to the solution of stratigraphic problems. The reason for this backwardness lies neither in the lack of good material (in the field) nor in the availability of equipment required for such studies, but principally in the failure of geologically-biologically educated students and acceptable materials to meet under favorable auspices. Both the geologist and the plant-anatomist are in part to blame for this state of affairs—the geologist for collecting uncritically and the anatomist for rejecting the poor material with unconcealed disdain—the whole performance resulting in general discouragement. It is hoped, however, that this unfortunate impasse can presently be overcome and that all good specimens of *Tempskya*, fossil wood, and other plant petrifactions may receive adequate attention. The collector should be advised that acceptable collecting will be seasoned with discrimination and will provide representative specimens, not necessarily bulky, but showing the essentials required for identification, such as the stems in *Tempskya*, the central core or pith in gymnosperms and angiosperms, as the case may be, and a generous portion of the best development of the wood. Thus, because fossil wood usually occurs as broken trunks or stumps of such large size as to dismay the uninformed collector, it becomes a matter of exercising nicety of judgment in selecting, with the help of a hand lens, only typical portions that have well-preserved features of diagnostic value.

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ZOOLOGY.—*The histology of nemic esophagi. V. The esophagi of* Rhabditis, Anguillulina, *and* Aphelenchus.[1] B. G. Chitwood, Bureau of Animal Industry, and M. B. Chitwood.

This is the fifth paper of a series dealing with the structure of the esophagi of various groups of nematodes. In the previous papers (Chitwood and Chitwood, 1934–1935) the histology of the esophagi of *Rhabdias eustreptos*, *Oesophagostomum dentatum*, *Heterakis gallinae*, and *Metestrongylus elongatus* has been described. The nomenclature in this paper is the same as that used in previous ones.

[1] Received March 13, 1935.

In the present paper, the esophagi of *Rhabditis terricola* and *R. lambdiensis* are described in full, while descriptions of the esophagi of *Anguillulina dipsaci* and *Aphelenchus avenae* are given in brief and in the form of a comparison with those of the species of *Rhabditis*.

THE ESOPHAGI OF RHABDITIS TERRICOLA AND R. LAMBDIENSIS

Both of these species were studied in detail, the results being nearly, but not entirely, identical. The description is based on *R. terricola*, comparisons with *R. lambdiensis* being made where differences were noted. Illustrations were made of the species of which the best sections were available.

GROSS MORPHOLOGY. The esophagus of *Rhabditis terricola* is 144 to 172μ long and consists of 3 major parts: A corpus distinctly subdivided into an anterior part, the precorpus, 58 to 70μ long, and a posterior part, the postcorpus, 24 to 34μ long; an isthmus 30 to 42μ long; and a bulb 30μ long. The precorpus is cylindrical, some of its tissue extending anteriorly and surrounding the mesostom and telostom. The lumen of the precorpus is somewhat subtriangular at the base of the stoma; immediately posterior to this point it becomes triradiate, each radius terminating distally in a small, incomplete "tube." In *R. lambdiensis* these "tubes" are much larger than in *R. terricola*. The "tubes" gradually become smaller in the posterior part of the precorpus and disappear in the postcorpus. The postcorpus takes the shape of a fusiform swelling commonly called the "median bulb"; its lumen is triradiate, the walls of the radii converging distally. The isthmus is a long, narrow region, the lumen being similar to that of the precorpus. The bulb is pyriform and contains a well developed valvular apparatus which alters the shape of the lumen. The cuticle lining the anterior part of the value is relatively thin, the lumen subtriangular to triradiate according to the stage of contraction. This is followed by the esophageal valve which consists of thickened parts of the cuticular lining to which muscles are attached.

NUCLEAR DISTRIBUTION. *Precorpus.* There are 18 nuclei in the precorpus of which 12 are of nerve cells (n_{1-12}) and 6 are of the radial muscle fibers (r_{1-6}). The nerve cell nuclei are arranged in 4 groups of 3 nuclei each, 1 nucleus being in the center of each esophageal sector. The first group (n_{1-3}) is situated a short distance from the anterior end of the corpus; the second, third, and fourth groups (n_{4-6}, n_{7-9}, and n_{11-12}) are situated in series, one behind the other. The radial nuclei (r_{1-6}) are arranged as a single group of 6 nuclei, 1 on each side of each esophageal sector, the group being situated near the base of the precorpus and between the third and fourth groups of nerve cell nuclei. In *Rhabditis lambdiensis* the same number of nuclei are present as in *R. terricola*, but the fourth group of nerve cell nuclei (n_{11-12}) is situated anterior to the radial nuclei (r_{1-6}).

Postcorpus. There are 28 nuclei in the postcorpus, comprising 6 radial

nuclei (r_{7-12}), 3 marginal nuclei (m_{1-3}), and 19 nerve cell nuclei (n_{13-31}). The marginal nuclei are situated near the anterior end of the postcorpus, 1 at the end of each esophageal radius; these nuclei are usually bilobed, the lobes being designated *a* and *b* (see m_{1a}, etc., in Fig. 1). This lobing of m_{1-3} is discussed in the description of the nuclei. The radial nuclei (r_{7-12}) are situated near the middle of the postcorpus and arranged as in the case of the first group (r_{1-6}). The nuclei of the nerve cells are arranged as a chain in the dorsal sector ($n_{13,16,23,28,29}$) and similarily in each subentral sector ($n_{14,17,19,21,24,26,30}$ and $n_{15,18,20,22,25,27,31}$). The nuclei in each sector are situated near the center of the sector, but the distance from the lumen varies considerably; for the

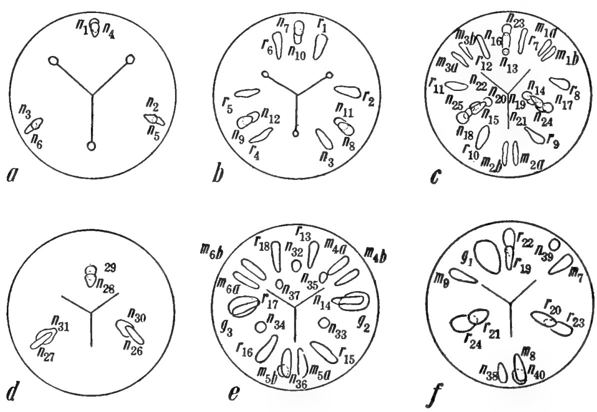

Fig. 1.—*Rhabditis terricola;* diagrammatic representation of the esophagus, a–b, precorpus; c–d, postcorpus; e–f, bulb.

relative positions see Figs. 1–2. The 3 most posterior nerve cell nuclei (n_{29-31}) are situated just posterior to the orifices of the subventral esophageal glands 1 being external to each of the 3 gland masses.

Isthmus. No nuclei are present.

Prevalvar region. The prevalvar and valvar regions of the esophagus are not distinctly separate. Contraction of the valve changes the relative positions of nuclei and for that reason the nuclei of the valvar region are included with those of the prevalvar region. There are a total of 17 nuclei in this region as follows: 6 radial nuclei (r_{13-18}), 3 bilobed marginal nuclei (m_{4-6}), 6 nerve cell nuclei (n_{32-37}), and 2 gland cell nuclei (g_{2-3}). The marginal nuclei are situated near the anterior end of the prevalvar region at the ends of the esophageal radii, 1 lobe lying on each side of each radius (Fig. 1). The radial muscle nuclei (r_{13-18}) are situated 4 to 10μ posterior to the marginal nuclei, 1 on each side of each sector. These nuclei are nearer the center of their sectors than those of the previous radial nuclei (r_{1-6} and r_{7-12}). The nerve cell nuclei n_{32-34} are situated near the posterior level of the radial nuclei, 1 in the center of each sector. The nerve cell nuclei n_{35-37} are situated 4 to 6μ posterior to n_{32-34}, 1 on each side of the dorsal sector, n_{35} being near the lumen at the

right side and n_{37} near the margin of the sector on the left side. The gland nuclei (g_{2-3}) are in the lateral parts of the subventral sectors or sometimes in the lateral parts of the dorsal sector; their position may be at the posterior level of the radial nuclei (Fig. 1) or at the level of n_{37}.

Postvalvar region. The postvalvar region contains 13 nuclei as follows 6 radial nuclei (r_{19-24}), 3 marginal nuclei (m_{7-9}), 3 nerve cell nuclei (n_{38-40}), and 1 gland nucleus (g_1). The radial nuclei are arranged in 2 groups of 3 nuclei each (r_{19-21} and $_{22-24}$), 1 nucleus in the center of each sector, the first group being 3 to 6μ anterior to the second group and nearer the lumen than the second group (Fig. 2). The marginal nuclei (m_{7-9}) are arranged as a single

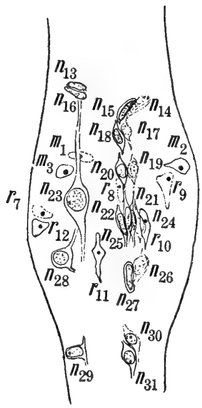

Fig. 2.—*R. lambdiensis;* longitudinal reconstruction of postcorpus.

group, 1 nucleus being at the side of each esophageal radius; their relative position varies considerably. The nerve cell nucleus n_{38} is situated on the right side of the ventral esophageal radius, whereas n_{40} is situated on the left side of the same radius and n_{39} on the dorsal side of the left subdorsal radius. The gland cell nucleus g_1 is near the posterior end of the postvalvar region on the right side of the dorsal sector.

ESOPHAGO-INTESTINAL VALVE. The esophago-intestinal valve is comparatively large and well developed in *Rhabditis* and consists of a trilobed internal structure and a circular external structure. Seven nuclei have been observed in these structures, but it is difficult to determine with certainty which nuclei belong to each of the two parts. Their positions vary somewhat, but usually there are 2 subdorsal nuclei, 2 dorsolateral or lateral nuclei, 2 subventral nuclei, and 1 ventral nucleus.

CHARACTER OF NUCLEI. The radial nuclei each contain 1 nucleolus or sometimes 2 nucleoli, moderately large in either case, surrounded by a nucleoplasm having little or no affinity for stains. The radial nuclei of the first group (r_{1-6}) are oval in cross section, (Fig. 3a); they are very much compressed longitudinally and often quite long. The radial nuclei of the second group (r_{7-12}) are similar to those of the first group in being oval in cross sec-

tion (Fig. 3b), but they may not be quite as elongate longitudinally (Fig. 2). The radial nuclei of the third group (r_{13-18}) are less oval in cross section (Fig. 3c), and not elongated longitudinally; there is considerable irregularity in shape. The radial nuclei of the fourth group (r_{19-21}) are nearly spherical and rest in a densely staining cytoplasm (Fig. 3e) which appears to be very similar to the cytoplasm of the esophageal glands. The radial nuclei of the fifth group (r_{22-24}) are usually somewhat compressed (Fig. 3f), their shapes depending on the state of contraction of their associated muscles.

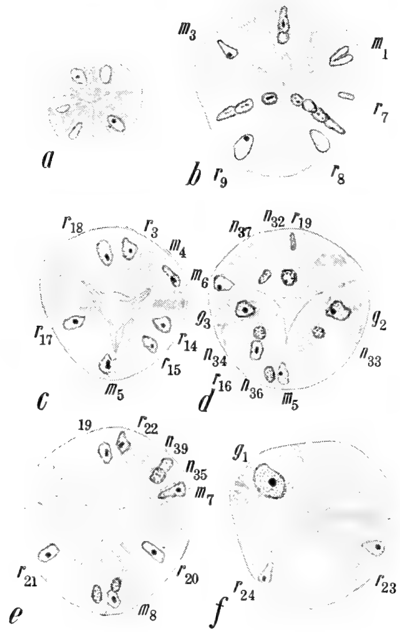

Fig. 3.—*R. terricola;* cross sections of the esophagus. a, precorpus at level of n_{1-6}; b, postcorpus, compare with Fig. 1a; *R. lambdiensis* c–f, bulb (serial sections).

The marginal nuclei are similar to the radials in that the nucleoplasm has little or no affinity for stain and each nucleus contains 1 or 2 nucleoli. The marginal nuclei of the first and second groups ($m_{1-3,4-6}$) are usually bilobed, each lobe containing a nucleolus. The lobes are joined anteriorly (Fig. 3 b–d). The third group of marginal nuclei (m_{7-9}) are similar in character to those of the second groups but not lobed (Fig. 3e). The nuclei of the first and second groups of marginals are apparently not lobed in *Rhabditis lambdiensis* (Fig. 2).

The nuclei of the esophageal glands (g_{1-3}) are larger than other nuclei of the esophagus with the exception of the nuclei of the fourth group of radials (r_{19-21}); they are generally similar to r_{19-21} being somewhat spherical and having 2 large nucleoli. The dorsal esophageal gland nucleus (g_1) is the largest nucleus of the esophagus (Fig. 3f), while the subventral nuclei (g_{2-3})

are of about the same size as the radial nuclei (r_{19-21}) (Fig. 3d). The nucleoplasm contains a few coarse basophilic granules and there is often a dense basophilic margin adjacent to the inconspicuous nuclear membrane.

The nuclei of the nerve cells of the esophagus differ from the other nuclei in that the nucleoplasm has a very definite affinity for basic stains. The basophilic material is concentrated next to the nuclear membrane for the most part, but clumps of granular material are present also near the center of the nucleus. Nucleoli were not always observed in the nerve cells but quite often a bilobed nucleolus was seen. The nerve cell nuclei are spherical or slightly elongated, and are so consistent in appearance that they may be easily recognized by reference to Figures 2 and 3. The protoplasm surrounding the nerve cell nuclei is relatively meager and no particular study of it was made. The neurones of the precorpus (n_{1-12}) all appear to be bipolar, as do all except 3 (n_{26-28}) of the postcorpus (Fig. 2). The exceptions (n_{26-28}) are neurones of the commissure which is situated in the posterior part of the postcorpus. The nerve cells which are situated posterior to n_{29-31} may be commissural cells also. The nerve cells of the prevalvar region (n_{32-36}) are commissural cells of the prevalvar and valvar region, while the remaining nerve cell of this region (n_{37}) and those of the postvalvar region (n_{38-40}) are probably a part of a postvalvar commissure; the later commissure has not been observed with certainty.

ESOPHAGEAL GLANDS. There are 3 esophageal glands, 1 dorsal and 2 subventral. The dorsal gland opens at the base of the glottoid apparatus through a very short transverse duct lined with cuticle. This duct dilates distally from the orifice, forming an ampulla which may or may not be lined with cuticle (facts uncertain). A narrow tube not lined with cuticle extends posteriorly from the ampulla through the middle of the dorsal sector. In the precorpus this tube is surrounded by a very meager amount of glandular protoplasm. In the postcorpus the glandular mass becomes a little larger and branches from the tube have been observed, and in the isthmus the glandular mass is represented only by a delicate strand of protoplasm. The dorsal gland becomes larger and lobed posterior to the valve and is most concentrated in the right side of the dorsal sector where its nucleus lies. The glandular protoplasm at the level of the nucleus is reticulate or facuolate.

The subventral esophageal glands open into the lumen of the esophagus near the base of the corpus, between the levels of the nerve cell nuclei n_{26-28} and n_{29-31}. Like the dorsal gland, each has a short transverse duct lined with cuticle which is connected with an ampulla; the protoplasm of the gland is rather extensive and reticulate in this region, the reticuli being apparently in direct communication with the lumen of the ampulla. The subventral gland masses become narrow and strand-like in the isthmus and remain of this character in the anterior part of the prevalvar region. In the posterior part of the prevalvar region and in the valvar region the gland masses are multilobed and reticulate.

THE ESOPHAGUS OF ANGUILLULINA DIPSACI

The esophagus of *Anguillulina dipsaci* (Fig. 4) cosists of the same general regions as the esophagus of *Rhabditis*, but differs in that the corpus and isthmus are proportionately thinner, and the bulbar region is cylindroid

Fig. 4.—*Anguillulina dipsaci;* longitudinal reconstruction of esophagus.

instead of pyriform and is entirely devoid of valves. This type of posterior swelling has been termed a pseudobulb although it is homologous with the bulb of *Rhabditis.* The lumen of the entire esophagus is greatly reduced (Fig. 5), being scarcely distinguishable except in the postcorpus (Fig. 5).

The precorpus apparently contains either 15 or 18 nuclei the arrangement and nature of which were not determined. The postcorpus contains 25 nuclei (Fig. 5) which appear to consist of 2 sets of radial nuclei (r_{1-6}, r_{7-12}), 1 set of marginal nuclei (m_{1-3}), and 10 nerve cell nuclei (n_{1-10}). These designations, it should be noted, were made on the basis of comparison with *Rhabditis* and not on purely structural grounds. The isthmus is exceedingly minute in cross

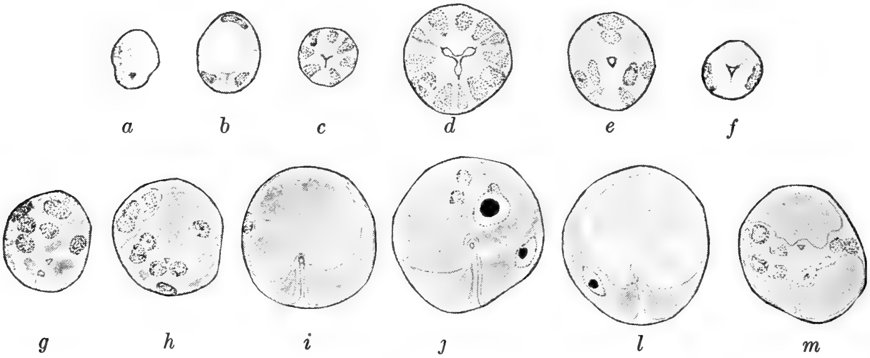

Fig. 5.—*A. dipsaci;* cross sections of esophagus. a–b, precorpus; c–f, postcorpus (serial sections); g–m, bulbar region (serial sections).

section and, like other forms, contains no nuclei. The bulbar region is most interesting, for although 30 nuclei have been found as in *Rhabditis,* there is practically no similarity in other respects. The musculature is exceedingly degenerate, and the esophageal gland tissue massive. Small nuclei are grouped near the anterior and posterior ends of the bulbar region (Fig. 5) with no apparent symmetry. The dorsal and subventral esophageal gland nuclei stand out in contrast, being of much greater size than the other nuclei. As shown by Goodey (1929), the dorsal esophageal gland opens into the esophagus at the base of the stylet and the subventrals open at the base of the postcorpus.

THE ESOPHAGUS OF APHELENCHUS AVENAE

The esophagus of *Aphelenchus avenae* is similar to that of *Anguillulina* with several outstanding exceptions, the most conspicous being the more massive development of the postcorpus and the degeneration of the bulbar region, the latter feature allowing the esophageal glands to lie in the body cavity. We find but 10 nuclei in the precorpus and 33 in the postcorpus (Fig. 6), the total number being the same as in *Anguillulina*. Of the 33 nuclei in the postcorpus, 15 (r_{1-12}, m_{1-3}) appear to check with those in *Anguillulina*, but the different arrangement of the remaining 18 nuclei makes their recognition impractical. The bulbar region appears to have 30 nuclei arranged without apparent symmetry (Fig. 6). Only the 3 esophageal gland nuclei

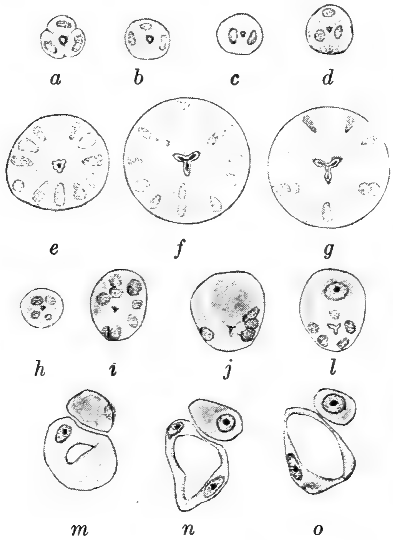

Fig. 6.—*Aphelenchus avenae;* cross sections of esophagus. a–d, precorpus; e–g, postcorpus; h–o, bulbar region.

are clearly recognizable. One point is notable, namely, that the esophageal glands, which extend posteriorly as a cylindroid mass of tissue, are surrounded by a nucleated covering. The fibrous tissue corresponding to these nuclei probably represents marginal or radial fibers. Goodey (1929) found that the dorsal esophageal gland opens in the anterior part of the postcorpus, whereas the subventrals open in the usual position; the writers were not able to verify or disprove this observation, but on the basis of sections it appears probable that he is correct.

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ZOOLOGY.—*The occurrence of the terrestrial amphipods,* Talitrus alluaudi *and* Talitrus sylvaticus, *in the United States.*[1] CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by MARY J. RATHBUN.)

The first record of the occurrence of a strictly terrestrial amphipod in the United States is that of Dr. J. Paul Visscher and Chester S. Heimlich (Science, **72**: 560, 1930). In 1930 they reported *Talitrus alluaudi* Chevreux abundant in a greenhouse at Columbus, Ohio, where they say it had survived for more than two years. In 1931 specimens of this species from a greenhouse at Flemington, New Jersey were sent to the Nation Museum for identification. These are the only known occurrences of *Talitrus alluaudi* in America.

T. alluaudi was described from the Seychelles Islands in 1896 where it occurs in rotton trunks of coconut trees and in the humus of forests. In temperate countries, however, it has been reported only from greenhouses.

In 1918 and 1919 Mrs. Kate Stevens, of the Natural History Museum, Balboa Park, San Diego, California, sent to the National Museum specimens of an amphipod which had been found upon a sidewalk in Balboa Park. Mr. Frank F. Gander in 1927 sent the Museum excellent specimens of the same species which he had found in Balboa Park. In December, 1934, and January, 1935, Prof. S. F. Light of the University of California sent the Museum further specimens of this species from a garden in Pasadena, California. Upon careful study, this amphipod proved to be *Talitrus sylvaticus* Haswell, and Mrs. Stevens' specimens of 1918 appear to be the first of this species to be taken in America.

The specimens sent to the Museum by Professor Light were secured in October, 1934, at Pasadena by Mrs. Merwin, who, in a letter to him, says, "The pests came during the recent rains in such quantities that they had to be cleared out of the gutters and literally shoveled from in front of the door. They even came into the house under the front door, but were dead when we found them. They seem to come up alive, and of a dark color, from between the bricks around the front door, though also found in garden gutters." In a later letter to Professor Light, dated November 17, 1934, she says, "The amphipods which you requested reappeared. In yesterday's rain they were found, though not in the former quantity, in our garden and a friend also reports them in Arcadia, which is about five miles east of Pasadena."

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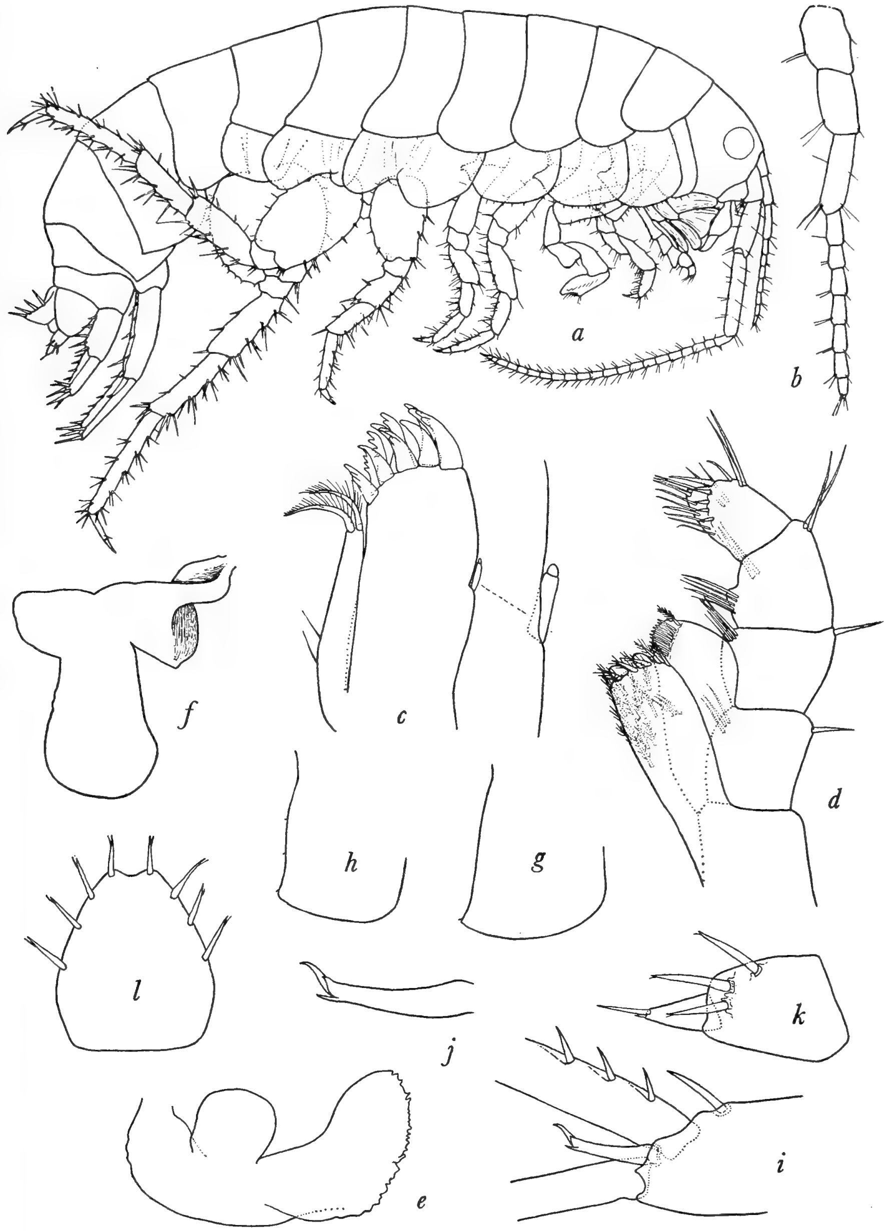

Fig. 1.—*Talitrus sylvaticus* Haswell, female. *a*, entire animal. *b*, antenna 1, top view, enlarged. *c*, maxilla 1. *d*, maxilliped. *e*, branchial vesicle of gnathopod 2. *f*, branchial vesicle of peraeopod 4. *g*, pleon segment 2. *h*, pleon segment 3. *i*, distal end of peduncle of uropod 1. *j*, spine at distal end of peduncle of uropod 1, enlarged. *k*, uropod 3. *l*, telson.

Recently there were sent to the National Museum for identification seventeen specimens of *Talitrus sylvaticus,* which were found in a dog's water pan at New Orleans, Louisiana, July 25, 1935.

T. alluaudi is a rather small species, which measures from 5 to 7 mm. in length exclusive of the antennae. The largest specimens of *T. sylvaticus* from California measure 13 mm. exclusive of antennae, while those from Louisiana measure from 5 to 11 mm.

Both of these amphipods are widely distributed. *T. alluaudi* has been recorded living in the open at the Seychelles Islands, Madagascar, Java, Gambier Archipelago, Taumotu Islands, and Mangareva. It has been recorded from greenhouses in Belgium, France, Monaco, Switzerland, Germany, Denmark, Hungary, British Isles, Sweden (Stephensen, 1935), the United States, and there is in the collection of the U. S. National Museum a specimen found in New York City in a shipment of celery from Bermuda.

Talitrus sylvaticus has been recorded from New South Wales, Victoria, Hawaii, Marquesas Islands, and now from the United States. It has been found from just above high tide up to 2,520 feet altitude.

As Calman, Stephensen, and others have pointed out, this species appears to be subject to considerable variation in some of its characters. The third pair of pleopods may be lacking altogether, or may be quite small with the branches vestigial. Chevreux said that specimens sent him by Chilton had third pleopods resembling the first, being biramous, though of smaller size. In the California specimens the third pleopods are very much as figured by Stephensen for the Marquesas specimens, consisting of a reduced peduncle and a single vestigial ramus. The telson also apparently is quite variable. Haswell, in his original description, says that the telson is cleft in the middle line. Thomson said it appeared quite entire to him. Sayce describes and figures the telson with margin entire. Stephensen states that it is cleft for one-third of the length, and figures it so. The specimens from California and Louisiana have the telson entire as I have figured it. Two specimens in the Museum collection from Hawaii, identified by A. O. Walker, agree in all characters with the specimens from the United States, and have the telson entire. It would appear then that the telson in *T. sylvaticus* may be either entire or partly cleft. The outer plate of the maxillipeds is rather broad, and rounding distally

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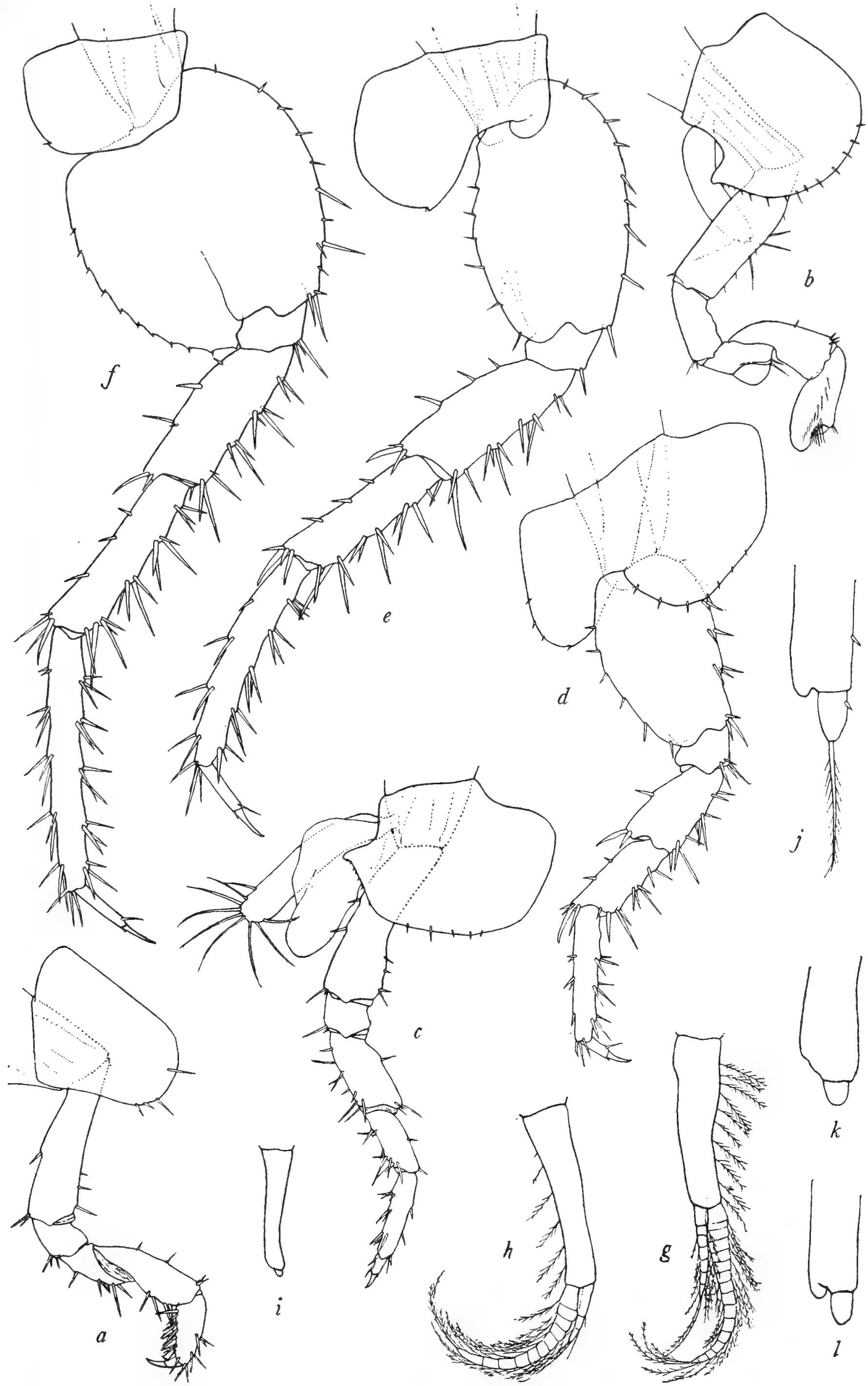
Fig. 2.—*Talitrus sylvaticus* Haswell, female. *a,* gnathopod 1. *b,* gnathopod 2. *c,* peraeopod 2. *d,* peraeopod 3. *e,* peraeopod 4. *f,* peraeopod 5. *g,* pleopod 1. *h,* pleopod 2. *i,* pleopod 3. *j, k, l,* distal end of pleopod 3, enlarged.



For explanation of Fig. 2, see bottom of opposite page.

in the Californian and Hawaiian specimens, whereas Chilton (Jour. Proc. Royal Soc. of N.S.W. **50:** 84, fig. 3) figures this plate as narrow and distally acute with the inside margin concave. This is a very peculiar discrepancy which I cannot account for. Stephensen (Bernice P. Bishop Mus. Bull. **142:** 20, 1935) states that the palp of the maxillipeds has a small fourth joint. In the specimens which I have examined the palp bears a small distal fleshy lobe marked off by a row of spinules, but which does not appear to be separated from the third joint.

Talitrus alluaudi may be expected to appear in greenhouses in other parts of the United States, as it is probably transported in the soil around the roots of plants. The occurrence of *Talitrus sylvaticus* in such widely separated localities as San Diego and New Orleans would seem to indicate that this species is much more common in the warmer parts of the United States than is now known. It is only when interest or curiosity prompts persons to have these creatures identified that their presence becomes known.

MALACOLOGY.—*Two new land shells from the Philippine Islands.*[1]

PAUL BARTSCH, U. S. National Museum.

In my paper on the land shells of the genus *Obba* from the Mindoro Province, Philippine Islands, published in Bulletin 100, volume 6, part 8, United States National Museum, I discussed *Obba listeri* Gray and figured the type species, as well as a number of subspecies belonging to this group. To these I added several more races in a paper published in the Journal of the Washington Academy of Sciences **24:** 318–323, 1934.

A collection recently received from Mr. Frederick S. Webber contains two unnamed races which are here described.

Obba listeri webberi, n. subsp. Fig. 1

Shell small, rather elevated, the spire forming a regular, almost hemispheric cone, the lower surface being much less rounded. Nuclear whorls 2.1 horn colored, the last half of the last turn with a pale brown band below the suture and another one occupying a median position. The postnuclear turns are of pale buff ground color and bear interrupted bands of brown, of which the first is near the summit, and the other a little above the middle, while the anterior half of the whorls is flecked and blotched with brown. The under side has an interrupted band about one-third of the distance between the peripheral keel and the umbilicus anterior to the keel, and the region between this interrupted band and the keel is also marked with flecks and blotches of brown. The nuclear whorls are marked by faint lines of growth. On the

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postnuclear whorls the lines of growth increase in strength and are strongly marked, very decidedly so on the last turn. The malleations are strongest anterior to the middle of the turns. The under surface is also strongly malleated and here the malleations extend almost to the umbilicus. The lines of growth here are even stronger than on the spire. The inner half of the base, including the umbilicus, is marked by well incised spiral striations. The umbilicus is rather narrow and about one-third covered by the parietal lip. The last whorl is constricted behind the inner lip, while the outer lip is decidedly deflected. The aperture is oval, slightly angulated at the periphery; peristome moderately thickened and reflected, the inner lip bearing a strong median tooth within.

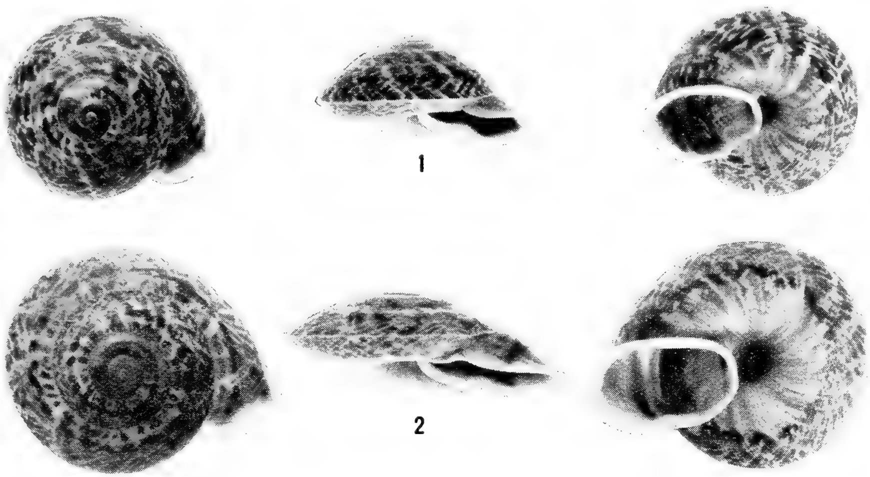


Fig. 1.—*Obba listeri webberi,* new subspecies. Fig. 2.—*Obba listeri catanduanensis,* new subspecies.

The type, U.S.N.M. Cat. No. 314057, was collected near the lighthouse on Tres Reyes Island near Marinduque. It has 4.6 whorls, and measures: Height, 12.8 mm.; greater diameter, 25.5 mm.; lesser diameter, 21.0 mm.

U.S.N.M. Cat. No. 314058 contains 3 paratypes from the same station, while 7 additional specimens are in Mr. Webber's collection. The lot yields the following average measurements: Height, 12.8 mm.; greater diameter, 25.9 mm.; lesser diameter, 21.3 mm.

This subspecies is much more elevated, with the spire more regularly conic and the base comparatively more flattened than any of the other named races of *Obba listeri.*

Obba listeri catanduanensis, n. subsp. Fig. 2

Shell of medium size, lenticular, of flesh colored ground color, mottled and splotched with dark chestnut brown on the upper surface and also on the outer half of the lower surface. Nuclear whorls 2.3 in the type, horn colored. The first half unicolor, while the succeeding portion shows a brownish flush near the suture and a median, rather broad brown band. The postnuclear portion of the shell shows the brown markings, arranged in more or less regular spiral zones, an interrupted band near the summit, a more or less median broken band and the rest fulgurated and mottled with brown. The nuclear whorls are marked by fine lines of growth, which are a little stronger

near the summit and increase in strength as the mollusk adds to the substance of the shell. The postnuclear whorls are strongly acutely keeled at the periphery, which flares slightly upward, and the surface is marked by malleations which are strongest on the outer half of the whorls, and somewhat irregular impressed spiral lines, which are coarser on the upper portion of the whorls. Suture poorly impressed; periphery sharp. The base is moderately arched, the outer half of the last whorl is strongly malleated, the inner half finely spirally striated. The lines of growth here are of the same strength as on the spire. The umbilicus is moderately open, and the shell is constricted immediately behind the inner lip, while the upper lip is decidedly bent upward. The aperture is broadly oval; peristome moderately expanded, thickened and reflected. A low tooth is present on the inside of the middle of the basal lip.

The type, U.S.N.M. Cat. No. 314056, is one of 3 specimens sent to us by Mr. Webber collected at Virac, Catanduanes. It has 4.5 whorls, and measures: Height, 10.6 mm.; greater diameter, 32.1 mm.; lesser diameter, 25.7 mm.

Two paratypes in Mr. Webber's collection yield the following measurements: Height, 12.8 and 12.1 mm.; greater diameter, 31.7 and 33.2 mm.; lesser diameter, 25.8 and 25.8 mm., respectively.

An additional specimen, U.S.N.M. Cat. No. 311069, received from Mr. Maxwell Smith, comes from Batu, Catanduanes, a station not far removed from Virac. It yields the following measurements: Height, 10.6 mm.; greater diameter, 32.8 mm.; lesser diameter, 24.7 mm.

This subspecies in general form resembles the typical race, but is much smaller and of much darker coloration.

ENTOMOLOGY.—*Some butterflies from eastern Virginia.*[1]

AUSTIN H. CLARK and LEILA F. CLARK, U. S. National Museum.

Since the days of Boisduval and Le Conte the butterflies of eastern Virginia have received little attention. Various collectors have visited the region, but only a few notes on some of the more unusual species have been published.

We have made a preliminary reconnaissance of this area, visiting Accomac and Northampton Counties on July 20–27, 1935, Princess Anne County on September 23–24, 1934, and Norfolk and Nansemond Counties on September 1–3, 1935. Although our time was limited, we feel that we secured a fairly complete representation of such butterflies as were flying when we were in any given locality, and therefore that our list is sufficiently detailed to serve as a basis for future intensive work.

Included in the list are records of nine species from Bayford, Northampton County, kindly given us by Dr. Florence Walker of Bayford, and of one from Lake Drummond which we owe to the courtesy of Dr. Paul Bartsch. With these included our list totals sixty-nine species.

[1] Received October 26, 1935.

We are under great obligations to Dr. Hugo Kahl, of the Carnegie Museum, Pittsburgh, Pa., who was so very kind as personally to bring to Washington the type specimens, male (Figs. 7, 8) and female (Figs. 5, 6), of *Atrytone dion* W. H. Edwards, and the unique type of *Atrytone dion* race *alabamae* Lindsey (Figs. 9, 10) for comparison with our material, and also to Mr. Ernest L. Bell, of Flushing, N. Y., who most courteously verified our determination of certain skippers.

Family NYMPHALIDAE: Subfamily Satyrinae: *Enodia creola* (Figs. 1, 2); western border of the Dismal Swamp and westward in wet woods, locally frequent, always with the following. *Enodia portlandia;* locally frequent to abundant in low wet woods throughout Princess Anne, Norfolk, and Nansemond Cos. *Neonympha gemma;* locally common in very wet woods in Princess Anne Co.; less common in Norfolk and Nansemond Cos. *Neonympha areolatus* var. *septentrionalis* (Figs. 3, 4); along Norfolk Southern Railway, about 1½ miles north of the North Carolina line; frequent. *Neonympha sosybius;* common everywhere in woods in Princess Anne, Norfolk, and Nansemond Cos. *Neonympha eurytus;* Bayford, Northampton Co., common in spring (F. Walker). *Cercyonis alope alope;* occasional throughout except in the eastern part of Princess Anne Co., where it is replaced by the following. *Cercyonis alope pegala;* Virginia Beach and Princess Anne; frequent.

Subfamily Nymphalinae: *Chlorippe clyton;* Bayford, Northampton Co., sometimes common (F. Walker). *Basilarchia arthemis astyanax;* occasional throughout. *Basilarchia archippus;* occasional throughout. *Junonia coenia;* everywhere common. *Pyrameis atalanta;* not seen in Princess Anne Co., elsewhere occasional to common. *Pyrameis virginiensis;* not seen in Princess Anne Co., elsewhere occasional to frequent. *Pyrameis cardui;* Wachapreague and Locustville, Accomac Co., occasional; Suffolk, occasional; Green Sea, frequent. *Vanessa antiopa;* Bayford, Northampton Co., October (F. Walker). *Polygonia comma;* Bayford, Northampton Co. (F. Walker). *Phyciodes tharos;* common throughout. *Brenthis myrina;* Bayford, Northampton Co., rare (F. Walker). *Argynnis cybele;* Bayford, Northampton Co., rare (F. Walker). *Euptoieta claudia;* occasional or locally frequent throughout.

Subfamily Danainae: *Danais plexippus;* occasional throughout but nowhere common.

Subfamily Libytheinae: *Libythea bachmanni;* Bayford, Northampton Co., one (F. Walker).

Family RIODINIDAE: *Charis virginiensis;* common just south of Virginia Beach.

Family LYCAENIDAE: Subfamily Lycaeninae: *Chrysophanus phlaeas hypophlaeas;* Wachapreague, Accomac Co., and Jamesville and Kiptopeke, Northampton Co. *Everes comyntas;* generally frequent throughout. *Lycae-*

nopsis argiolus pseudargiolus; not seen in Princess Anne Co., elsewhere locally frequent.

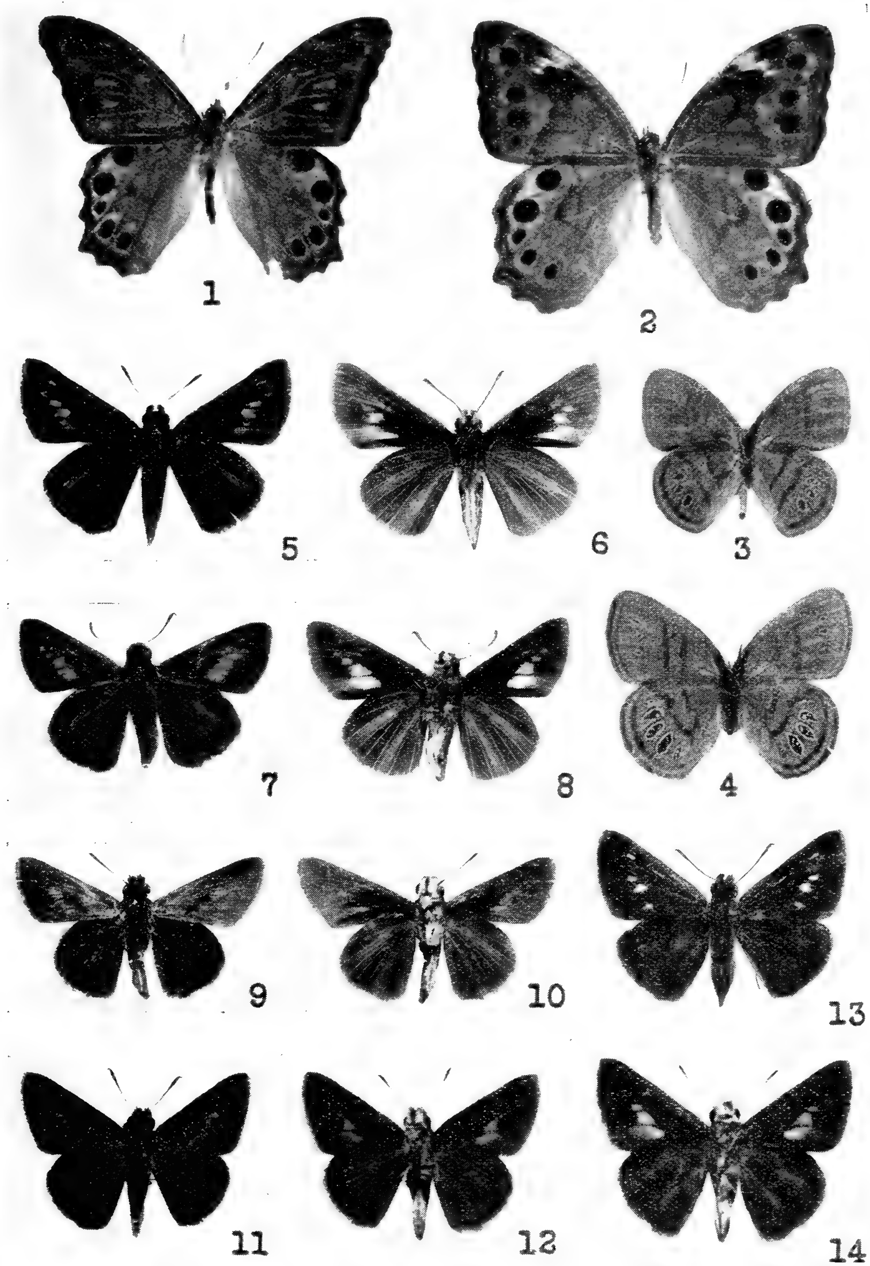
Subfamily THECLINAE: *Atlides halesus;* Lake Drummond, October 27 (P. Bartsch). *Strymon cecrops;* occasional to frequent in woods throughout. *Strymon melinus;* generally frequent throughout. *Mitoura gryneus;* Bayford, Northampton Co.

Family PAPILIONIDAE: Subfamily PIERINAE: *Eurema lisa;* frequent to abundant throughout. *Eurymus philodice philodice;* New Church and Wachapreague, Accomac Co., and Virginia Beach; rare; *Eurymus philodice eurytheme;* abundant everywhere in Accomac and Northampton Cos., infrequent in Princess Anne, Norfolk, and Nansemond Cos. *Zerene caesonia;* Bayford, Northampton Co., one (F. Walker). *Catopsilia eubule;* everywhere frequent in Nansemond, Norfolk, and Princess Anne Cos., becoming abundant near the sea; frequent along the western shore of Northampton and Accomac Cos., and at Chincoteague Island; one female of form *sennae* from Virginia Beach. *Anthocaris genutia;* Bayford, Northampton Co., common in spring (F. Walker). *Pieris rapae;* frequent near farms throughout, though generally not very common.

Subfamily PAPILIONINAE: *Papilio polyxenes asterius;* frequent throughout, and the commonest swallowtail in Accomac and Northampton Cos. *Papilio cresphontes;* frequent at Kiptopeke and Bayford, Northampton Co., and also found at Wachapreague, Accomac Co., and Little Creek and Deep Creek, Norfolk Co. *Papilio glaucus;* not seen in Princess Anne Co., but elsewhere frequent. *Papilio troilus;* frequent throughout; least common in Princess Anne Co. *Papilio palamedes;* the most abundant swallowtail in and near the Dismal Swamp; generally common in suitable situations in Princess Anne, Norfolk, and Nansemond Cos.

Family HESPERIIDAE: Subfamily PYRGINAE: *Goniurus proteus;* Virginia Beach, one. *Epargyreus tityrus;* not seen in Princess Anne Co., occasional to common elsewhere. *Thorybes bathyllus;* occasional throughout. *Thorybes confusis;* Princess Anne, one. *Pyrgus communis;* Wachapreague and Harborton, Accomac Co., and Bayford, Northampton Co. *Pholisora catullus;* not seen in Princess Anne Co., elsewhere locally frequent. *Thanaos juvenalis;* Wachapreague and Dahl Swamp, Accomac Co. *Thanaos horatius;* occasional to frequent throughout. *Thanaos terentius;* Wachapreague and Dahl Swamp, Accomac Co., and Kiptopeke, Northampton Co.

Subfamily HESPERIINAE: *Ancyloxypha numitor;* frequent to common throughout. *Hylephila phylaeus;* occasional to frequent throughout. *Atalopedes campestris;* the commonest skipper in Accomac and Northampton Cos.; occasional in Nansemond Co.; not seen in Norfolk and Princess Anne Cos. *Talides manataaqua;* on the line of the Norfolk Southern Railway, about 1½ miles north of the North Carolina border; frequent. *Talides themistocles;* occasional throughout. *Wallengrenia otho egeremet;* Dahl Swamp and Cashville, Accomac Co.; Bayford, Northampton Co.; on the line of the



Figs. 1, 2.—*Enodia creola*, Dismal Swamp, Va., male, Sept. 1, 1935 (1), and female, Sept. 2, 1935 (2). Figs. 3, 4.—*Neonympha areolatus* var. *septentrionalis*, near the Dismal Swamp, Va., Sept. 3, 1935, male (3) and female (4), under side. Figs. 5, 6.—*Atrytone dion* Edwards, female, type specimen, Whiting, Indiana, upper (5) and under (6) sides. Figs. 7, 8.—*Atrytone dion* Edwards, male, type specimen, Whiting, Indiana, upper (7) and under (8) sides. Figs. 9, 10.—*Atrytone dion* race *alabamae* Lindsey, male, type specimen, from Mobile County, Albama, upper (9) and under (10) sides. Figs. 11, 12.—*Atrytone dion alabamae*, male, Dahl Swamp, Accomac Co., Va., July 23, 1935, upper (11) and under (12) sides. Figs. 13, 14.—*Atrytone dion alabamae*, female, Dahl Swamp, July 25, 1935, upper (13) and under (14) sides.

Norfolk Southern Railway, about 1½ miles north of the North Carolina border. *Poanes zabulon;* Bayford, Northampton Co.; near Adam's Swamp, Nansemond Co., about 1½ miles north of the North Carolina border and about 3 miles west of the Dismal Swamp. *Poanes yehl;* Green Sea, one male; Dismal Swamp, near Suffolk, one female. *Atrytone dion alabamae* (Figs. 11–14); Dahl Swamp, Accomac Co., common; Green Sea, Norfolk Co., one female. *Atrytone ruricola;* Dismal Swamp; Green Sea. *Lerema accius;* the commonest skipper in Nansemond, Norfolk, and Princess Anne Cos.; not seen in Northampton or Accomac Cos. *Amblyscirtes textor;* frequent everywhere in wet woods in Nansemond, Norfolk, and Princess Anne Cos., and locally common and even abundant about the Dismal Swamp. *Amblyscirtes carolina;* western border of the Dismal Swamp about 8 miles south of Suffolk, three, in company with large numbers of the preceding. *Lerodea l'herminier;* western border of Dismal Swamp, frequent: Virginia Beach, one. *Lerodea eufala;* Green Sea, Norfolk Co., one. *Prenes panoquin;* Wachapreague and Chincoteague Island, Accomac Co., abundant on *Borrichia frutescens;* Hack's Neck, Accomac Co.; Bayford, Northampton Co., common. *Prenes ocola;* Virginia Beach, one; Dismal Swamp, one.

ENTOMOLOGY.—*The bees of the genus* Agapostemon (*Hymenoptera: Apoidea*) *occurring in the United States.*[1] GRACE ADELBERT SANDHOUSE, Bureau of Entomology and Plant Quarantine. (Communicated by S. A. ROHWER.)

This study of the *Agapostemon* occurring in the United States was undertaken to facilitate the identification of these species. The results presented in this paper are based on the examination of about four thousand specimens and many dissections of the male genitalia.

The collection of the *Agapostemon* in the United States National Museum has served as a basis for this revisionary study. This was supplemented by loans from the American Museum of Natural History (through Dr. F. E. Lutz), the Academy of Natural Sciences of Philadelphia (through Mr. E. T. Cresson, Jr.), the Illinois State Natural History Survey (through Dr. T. H. Frison), Cornell University (through Dr. J. C. Bradley), McGill University (through the late Mr. Albert F. Winn), South Dakota State College (through Prof. H. C. Severin), the Bureau of Biological Survey (through Mr. J. R. Malloch), the University of Minnesota (through Dr. C. E. Mickel), and the private collections of Drs. Joseph Bequaert, Harold Morrison and T. B. Mitchell, Prof. H. A. Scullen, Mr. C. N. Ainslie

[1] Published by permission of the Chief of the Bureau of Entomology and Plant Quarantine. Received November 8, 1935.

and the late Mr. C. L. Fox (whose collection is now in the California Academy of Sciences).

I have also studied the types in the Academy of Natural Sciences of Philadelphia and wish to take this opportunity to express my appreciation of the courtesies shown me by Mr. E. T. Cresson, Jr., during my visit to that institution. Dr. T. D. A. Cockerell and the late Dr. James Waterston kindly compared specimens with the types of Smith's species in the British Museum. To Mr. E. P. Van Duzee I am indebted for the opportunity of examining certain paratypes from the collection of the California Academy of Sciences.

Genus AGAPOSTEMON Guerin

Agapostemon Guerin, Iconog. Regne Animal de G. Cuvier, Insects **3**: 448. 1844. Genotype, *Apis* (*Andrena*) *femoralis* Guerin. (Monobasic)

Agapostemon F. Smith, Cat. Hymen. Ins. Brit. Mus. **1**: 85–86, pl. 4, figs. 1–4. 1853.—Provancher, Natur. Canad. **13**: 203. 1882.—Petite Faune Ent. Canad., Hymen., p. 703. 1883.—Robertson, Trans. Acad. Sci. St. Louis **7**: 325. 1897.—Crawford, Proc. Nebr. Acad. Sci. **7**: 159. 1901.

HALICTI INTERMEDII, Groupe *Agapostemon* Vachal, Misc. Ent. **11**: 89. 1903. —**19**: 12. 1911.

The name *Agapostemon* was proposed by Guerin in 1844 for a subgenus of *Apis* with *Apis* (*Andrena*) *femoralis* Guerin the only species included, although he mentioned having seen other species with the characters which he uses to define the subgenus. His definition is as follows: "*Nous connaissons plusieurs espèces a cuisses ainsi renflees. Ce sont des males. Peut-etre jugera-t-on a propos de les reunir en un sous-genre, que nous proposerions de nomer Agapostemon. Il serait aux Andrenes ce qu'est le genre Nomia parmi les Halictes.*" Frederick Smith (1853) was the first to give *Agapostemon* generic rank, in this being followed by Cresson, Robertson, Dalla Torre, Cockerell and Crawford; he included in it seven species, four of which were described as new. His discussion of generic characters was based chiefly on those of the head, especially of the trophi. Vachal (1903) treated *Agapostemon* as a group or subgenus of *Halictus* (*Halicti agapostemones*).

This genus can be separated from the other genera of the Halictinae represented in the nearctic fauna by the length of the posterior tibia, which is as long as, or longer than, the combined length of the tarsal joints, while in the others it approximates more nearly that of the metatarsus alone. The sexual dimorphism is so great that some characters will have to be given separately for each sex. The characters of the genus as here limited are as follows:

Head, when viewed from the front, appearing rounded except where the clypeus extends below the lower margins of the eyes. Eyes large and bare, forming the lateral boundaries of the head for most of its length; their inner margins quite strongly emarginate. Front foveolate-punctate, when viewed laterally, level with the eyes, occupying about one-half the space from vertex

to apex of clypeus. Clypeus and postclypeus of equal length, strongly convex, with well-separated punctures; clypeus extending at least half its length below the lower margins of the eyes; apical margin truncate. Gena (malar space) very short. Postgenae declivous behind the eyes, striate-punctate. Labrum of female with basal portion as wide as truncate apex of clypeus, sides nearly parallel; apical portion about one-third as wide as basal, sides converging toward apex and fringed with curved bristles; labrum of male nearly triangular, sides slightly convex, basal portion with transverse elevation. Mandible of female strongly curved, apically bidentate, inferior tooth much larger and extending beyond superior; mandible of male edentate, narrowing gradually to pointed apex. Antennae inserted about half way between apical margin of clypeus and postocellar line; scape of female a little more than one-third length of antenna, scape of male about as long as joints two to four.

General contour of thorax more regular than that of honeybee (see Snodgrass, *Anatomy and physiology of the honeybee*, fig. 231, 1925.), that of female more robust than that of male. Prothorax showing no striking modifications; posterior margin of prothoracic lobe heavily fringed with hair. Mesoscutum of male with uniform, nearly contiguous punctures, varying little among the species; that of female closely uniformly punctate or with punctures of two distinct sizes, the punctation specifically distinct. Metatergum irregularly foveolate. Mesopleura foveolate. Metapleura of female with somewhat irregular, but principally horizontal low carinae, of male foveolate. Propodeum extending caudad to a distance about equal to length of metatergum and thence abruptly declivous to attachment of abdomen; posterior surface irregularly carinate, enclosed by a sharply defined carina, more strongly developed in female; dorsal surface lacking the somewhat crescentic disk or enclosed space found in many of the other halictine bees; sculpturing consisting of low carinae variously arranged; lateral surfaces with nearly horizontal low carinae, between them rows of small but deep punctures. Tegula smooth, ovoid, about same color as basal wing-veins. Wings varying little from those of related genera and little within the genus; hyaline, slightly yellowish infumate, usually slightly darker apically; second cubital cell of male distinctly narrower.

Legs of female and front and middle legs of male not varying in structure within the genus; hind legs of male showing greatest modification and varying with the species. In hind leg of female, posterior surface of femur with a single row of very long and strongly curled branched hairs; anterior surface with several rows of shorter branched hairs; hind tibia with knee-plate obsolescent, posterior margin with long simple hairs, anterior margin with variously branched hairs; inner calcar pectinate, usually with from three to five broad spatulate teeth. Hind leg of male with femur usually thickened, distinctly wider than trochanter and toothed below near apex; tibia broader than metatarsus; metatarsus frequently enlarged and toothed; first and second joints of tarsus coalescent.

Abdomen of female broadly ovoid, length as ordinarily extended about twice its width at apex of second tergite; tergites finely and uniformly punctured; fifth tergite with median rima, laterally densely pubescent; sixth tergite with well-defined pygidial area; second to fifth with basal fasciae of pale appressed hair. Abdomen of male more slender and frequently curved downward at apex; seven tergites, but only six sternites exposed; tergites uniformly punctured and pubescent, seventh with a distinct polished oval pygidial area bounded apically and laterally by a carina; sternites one to

six varying little within the genus, seventh and eighth very small and lying against ventral surface of basal ring, with slight specific differences.

In both sexes head and thorax brilliant blue-green (as in *Chrysis*); abdominal tergites of female concolorous with thorax, or black or brown, tergites of male transversely banded black and yellow, the black sometimes obscurely tinged with blue-green. Legs of female brown or yellowish brown, of male yellow variously marked with black.

The genitalia of the male are specifically distinct and a study of them has assisted greatly in determining the amount of variation within the species. Since the paper by Beck (Proc. Utah Acad. Sci. 10: 89–137, pls. I–VII. 1933) gives the results of rather extensive studies in homologies of parts of the male genitalia of bees, his terminology was used in labeling these parts. For a description of the genitalia of a species of *Agapostemon*, see page 109 and plate VII, figures 168–169 of his paper. In the present paper dorsal and ventral views of the entire genitalia are given for *Agapostemon virescens* (Fabricius), since they approach most nearly those of the genotype, *femoralis* (Guerin), and for each species a dorsal and slightly caudal view of only the distal portion of the coxopodite and stylus, since they present the greatest specific differences.

KEY TO THE SPECIES OF AGAPOSTEMON OCCURRING IN THE UNITED STATES

1. Females 2
   Males 10
2. Abdominal tergites not concolorous with the thorax, but black, brown or testaceous 3
   Abdominal tergites concolorous with the thorax, brilliant green or blue-green 6
3. Apex of clypeus black. Abdominal tergites entirely black; base of first tergite with lateral patches of white hair; hair on apices of tergites black. Posterior surface of propodeum with oblique carinae. Front and middle legs dark brown. Tegular and wing-veins brown-testaceous 4
   Apex of clypeus yellow, or black and yellow. Abdominal tergites testaceous, brown, or, if nearly black, always tinged with brown or blue-green, especially apically; base of first tergite with a wide band of dense white hair; hair on apices of tergites white, except on the fifth, where it is yellowish or brownish. Posterior surface of propodeum irregularly carinate. Front and middle legs largely or partly yellow. Tegula and wing-veins yellow-testaceous 5
4. Base of mandible yellow. Postgenae laterad of the hypostomal carinae with several moderately coarse striae. Hair on posterior legs strongly infuscated. Head and thorax brilliant green, usually not at all bluish. Carinae on dorsal surface of propodeum not forming a median triangle. Punctures on abdominal tergites separated by twice the diameter of a puncture. Species smaller, 11 to 12 mm. long. . . . . *virescens* (Fabricius)

Base of mandible reddish black. Postgenae laterad of hypostomal carinae very finely striate. Hair on posterior legs yellowish white. Head and thorax green, usually strongly tinged with blue. Carinae on dorsal surface of propodeum forming a median triangle. Punctures on abdominal tergites separated by the diameter of a puncture. Species larger, 14 to 15 mm. long . . . . *coloradinus* (Vachal)

5. Scape largely yellow. Femora and abdomen testaceous. Yellow of clypeus extending upwards in the middle to form a triangle; apical margin yellow . . . . *melliventris* Cresson

Scape dark brown. Femora and abdomen dark brown, the apex of the latter faintly tinged with blue-green. Yellow of clypeus not extending upwards in the middle; apical margin black . . . . *melliventris* var. *plurifasciatus* (Vachal)

6. Mesoscutum with punctures nearly uniform in size and nearly contiguous 7

Mesoscutum with well-separated punctures of two distinct sizes 9

7. Mesoscutum not at all rugose between punctures, more finely and uniformly punctured. Abdominal tergites appearing dull, with punctures separated by less than their diameter. Dorsal surface of propodeum dull, with irregularly anastomosing carinae. Pubescence strongly tinged with ochreous. Wings dusky, especially at the apices . . . . *splendens* (Lepeletier)

Mesoscutum rugose between punctures, more coarsely punctured, foveolate-punctate on the anterior and lateral portions. Abdominal tergites shining between punctures, which are separated by more than their diameter. Dorsal surface of propodeum shining, with longitudinal carinae. Pubescence and wings paler 8

8. Species larger, usually about 12 to 13 mm. long; blue-green. Pubescence white. Sixth abdominal tergite with hair on the basal third entirely pale . . . . *cockerelli* Crawford.

Species smaller, usually less than 10 mm. long; green, not at all bluish. Pubescence distinctly yellowish. Sixth abdominal tergite with hair fuscous, except for a small patch of yellowish hair at each side; no pale hair on the median basal portion . . . . *radiatus* (Say)

9. Smaller punctures of mesoscutum usually separated by about their diameter. Dorsal surface of propodeum irregularly carinate, usually with a distinct median triangular area. Species larger, about 12 mm. long. Pubescence slightly tinged with yellow . . . . . . *texanus* Cresson

Smaller punctures of mesoscutum usually separated by at least twice their diameter. Dorsal surface of propodeum with longitudinal carinae. Species smaller, about 10 mm. long. Pubescence pure white . . . . *angelicus* Cockerell

10. Base of first abdominal tergite usually of a brownish tint, but never distinctly black; dark bands on the intermediate tergites scarcely

one-third the length of a tergite. Legs distad of the trochanters pale, except for a brownish spot at the apex of the hind femur and one at base of hind tibia; hind femur hardly wider than the trochanter, the tooth near the apex weakly developed. Wings clear testaceous....11

Base of first abdominal tergite black; dark bands on the intermediate tergites fully one-half the length of a tergite. Legs distad of the trochanters conspicuously marked with black; hind femur distinctly wider than trochanter, the tooth near the apex strongly developed. Wings quite strongly infumated..............................12

11. Trochanters of front and middle legs yellow, of the hind legs tinged with green. Scape entirely yellow, or with a small brownish dot on upper side near the apex. Dark bands on the abdominal tergites not reaching the lateral margins................*melliventris* Cresson

Trochanters of all the legs green. Scape with the upper side brown. Dark bands on the abdominal tergites reaching the lateral margins.. ....*melliventris* var. *plurifasciatus* (Vachal)

12. Dark bands on the abdominal tergites strongly tinged with metallic blue-green, which is especially conspicuous laterally on the apical segments...13

Dark bands on the abdominal tergites dull black, with no metallic tints..14

13. Species larger, 11 to 12 mm. long, usually more yellowish green, with pubescence slightly yellowish. Dorsal surface of propodeum with a distinct triangle in the middle. Front and middle trochanters with varying amounts of black and yellow; if largely black, then there are marks of black on the bases of the femora; hind tibia always with a long black mark on the anterior surface, often also with one on the posterior surface.............................*texanus* Cresson

Species smaller, about 9 mm. long, usually more bluish green, with pubescence pure white. Dorsal surface of propodeum without a median triangle, the carinae coarser. All the trochanters black, but no black on the bases of the femora; hind tibia with a long black mark on the posterior surface, but never with one on the anterior surface ....*angelicus* Cockerell

14. Hind femur swollen so strongly that its width is distinctly more than one-half of its length.....................................15

Hind femur not so strongly swollen, its width less than one-third of its length..16

15. Black bands on the abdominal tergites occupying more than half of their length; fifth and sixth abdominal sternites largely black. Hind femur a little more than one-half as wide as long. Dorsal surface of propodeum dull, with irregularly anastomosing carinae. Wings dusky ....*splendens* (Lepeletier)

Black bands on the abdominal tergites occupying less than half of

their length; basal two-thirds of fifth sternite and most of sixth yellow. Hind femur about three-fourths as wide as long. Dorsal surface of propodeum more polished, with carinae on the entire length on the middle and laterally on the basal fourth principally longitudinal. Wings clear hyaline . . . . *cockerelli* Crawford

16. Species smaller, about 9 mm. long or less. Dorsal surface of propodeum with longitudinal carinae. Punctures of mesoscutum contiguous, giving a dull, almost velvety appearance. Abdominal sternites more than half yellow; apical margin of the fourth with a median green spot, laterally with two stout bristles on each side. Front and middle trochanters largely yellow; bases of femora yellow . . *radiatus* (Say)

    Species larger, about 11 mm. long. Dorsal surface of propodeum with irregularly anastomosing carinae. Punctures of mesoscutum more widely separated, the interspaces shining. Abdominal sternites largely black; apical margin of the fourth lacking the green spot in the middle between the lateral bristles. All the trochanters black; bases of femora strongly marked with black 17

17. Black markings on the posterior surfaces of the front and middle femora confined to the basal halves, of the hind femur to the apical third; posterior surface of the hind tibia yellow, except for a small black spot near the apex; front and middle tibiae with basal spots of black. Abdominal tergites with much black hair apically. Second and third sternites with hair quite sparse; sixth with a low median carina. Head and thorax brilliant green, usually not at all bluish. Carinae on the dorsal surface of the propodeum not forming a median triangular area . . . . *virescens* (Fabricius)

    Black markings on the posterior surfaces of all the femora and tibiae extending nearly the length of the surfaces. Abdominal tergites with hair largely white. Second and third sternites with conspicuous apical fringes of white hair; sixth without a median carina. Head and thorax distinctly bluish green. Carinae on dorsal surface of propodeum forming a median triangle . . . . *coloradinus* (Vachal)

Agapostemon virescens (Fabricius)

Andrena virescens Fabricius, Syst. Ent., p. 378, n. 12. 1775.—Spec. Insect. **1**: 474, n. 16. 1781.—Mant. Insect. **1**: 299, n. 18. 1787.—Olivier, Encycl. Method. Ins.; Hist. Nat. Ins. **1**: 137, n. 23. 1789.—Fabricius, Ent. Syst. **2**: 314, n. 28. 1798.

Apis (Andrena) virescens Gmelin, Linné, Syst. Nat., Ed. 13a, 1 (pt. 5): 2792, n. 185. 1790.

Apis virescens Christ, Natur. d. Insect., p. 154. 1791.

Andrena nigricornis Fabricius, Ent. Syst. **2**: 313, n. 28. 1793.—Coquebert, Illustr. Iconogr. Ins. **2**: 63, T. 15, fig. 7. 1801.

Megilla virescens Fabricius, Syst. Piez., p. 333, n. 23. 1804.

Centris nigricornis Fabricius, Syst. Piez., p. 360, n. 33. 1804.

Hylaeus nigricornis Klug, Magaz. f. Insectenk. **6**: 222. 1807.—Magaz. Ges. naturf. Fr. Berlin **2**: 57, n. 85. 1808.

Halictus nigricornis Say, Boston Jour. Nat. Hist. **1:** 394, n. 1. 1837.—Leconte, Writ. Thomas Say **2:** 772, n. 1. 1859.
Halictus dimidiatus Lepeletier, Hist. Nat. Ins. **2:** 283, n. 24. 1841.
Agapostemon nigricornis Smith, Cat. Hymen. Ins. Brit. Mus. **1:** 86, n. 1. 1853.—Cresson, Trans. Amer. Ent. Soc. suppl., p. 293. 1887.
?*Agapostemon tricolor* Provancher (not Lepeletier), Natur. Canad. **13:** 203. 1882.—Petite Faun. Ent. Canad. Hymen., p. 703. 1883.
Augochlora radiata Provancher, Natur. Canad. **13:** 205. 1882.—Petite Faun. Ent. Canad. Hymen., p. 705. 1883.—Dalla Torre, Cat. Hymen. **10:** 96 (in part). 1896.
Apis viridula Cresson (not Fabricius), Trans. Amer. Ent. Soc., suppl., p. 309. 1887.
Agapostemon bicolor Robertson, Trans. Amer. Ent. Soc. **20:** 148. 1893.—Dalla Torre Cat. Hymen. **10:** 97. 1896.
Agapostemon viridula Robertson (not Fabricius), Trans. Amer. Ent. Soc. **22:** 118. 1895.
Agapostemon virescens Dalla Torre, Cat. Hymen. **10:** 98 (in part). 1896.—Cockerell, Ann. Mag. Nat. Hist. (9) **8:** 363. 1921.
Agapostemon viridulus Robertson, Trans. Acad. Sci. St. Louis **7:** 325. 1897. —Crawford, Proc. Nebr. Acad. Sci. **7:** 173. 1901.
Halictus (*Agapostemon*) *viridulus* Vachal, Misc. Ent. **11:** 90, 101. 1903.
Halictus (*Agapostemon*) *virescens* Viereck, Conn. State Geol. & Nat. Hist. Survey Bull. **22** (pt. 3): 704.

Type.—Female, in the Banksian Collection at the British Museum, where it was seen by Cockerell in 1921 and the identity of the species confirmed. The present locations of the types of *nigricornis* and of *dimidiatus* are unknown to the writer. The types of *bicolor* are in Robertson's collection.

Distribution.—Insofar as is known, distributed throughout the United States from coast to coast north of 40 degrees latitude, extending down the Mississippi Valley and eastern slope of the Rocky Mountains to Louisiana and Texas. About 700 specimens have been examined from the following states: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, District of Columbia, North Carolina, Alabama, Kentucky, Tennessee, Ohio, Michigan, Indiana, Illinois, Iowa, Minnesota, Missouri, Louisiana, Texas, Colorado, Kansas, Nebraska, North Dakota, South Dakota, Montana, Wyoming, Idaho, Oregon, and Washington.

Of the nearctic species, *virescens* and the closely related *coloradinus* are nearest to the genotype, *femoralis*. *Virescens* can be separated from *coloradinus* by the characters given in the key. The male is readily distinguished by the median carina on the sixth sternite. The female is the only one having a black abdomen which is widely distributed throughout the United States.

Agapostemon coloradinus (Vachal), n. comb.

Agapostemon coloradensis Crawford, Proc. Nebr. Acad. Sci. **7:** 163. 1901.—Cockerell, Ann. Mag. Nat. Hist. (7) **19:** 532. 1907.
Halictus (*Agapostemon*) *coloradinus* Vachal, Misc. Ent. **11:** 90. 1903. (Proposed for *Halictus* (*Agapostemon*) *coloradensis* Crawford, not *Halictus* (*Augochlora*) *coloradensis* Titus.)

Agapostemon tyleri Cockerell, Ann. Mag. Nat. Hist. (8) **20:** 241. 1917 (new synonymy).
Agapostemon martini Cockerell, Pan-Pacific Ent. **3:** 153, female only. 1927 (new synonymy).

Type.—Female (lectotype selected by Crawford), southern Colorado, in the collection of the United States National Museum. The specimen on which Cockerell based the description of the male of *coloradinus* and the type and "cotype" (allotype) of *tyleri* are also in this collection. The type of *martini* is in the collection of the California Academy of Sciences.

Distribution.—Apparently limited to the southern Rocky Mountain region from South Dakota and Colorado to western Texas, southern Arizona and Mexico. Only 38 specimens have been seen from the following states: Texas, Colorado, Nebraska, South Dakota, Utah and New Mexico; also from Mexico.

This species is closely related to *virescens* and apparently replaces it in the southwestern part of the United States. The type of *martini* was not seen, but the description of the female agrees well with the type of *coloradinus*. Both sexes of *tyleri* have been compared with *coloradinus* and found to be identical.

Agapostemon melliventris Cresson

Agapostemon melliventris Cresson, Trans. Amer. Ent. Soc. **5:** 101. 1874.—Rept. Geogr. & Geol. Explor. & Surv. 100th Merid. **5:** 721, pl. 33, fig. 4. 1875.—Trans. Amer. Ent. Soc., suppl. p. 293. 1887.—Dalla Torre, Cat. Hymen. **10:** 97. 1896.—Cockerell, Trans. Amer. Ent. Soc. **24:** 146. 1897.—Crawford, Proc. Nebr. Acad. Sci. **7:** 164. 1901.
Agapostemon digueti Cockerell, Proc. Calif. Acad. Sci. **12:** 539. 1924 (new synonymy).

Type.—Female, lectotype, Nevada, in the collection of the Academy of Natural Sciences, Philadelphia. The types of *digueti* are in the collection of the California Academy of Sciences. The synonymy of *digueti* is based upon a study of paratypes of both sexes in the collection of the United States National Museum.

Distribution.—Apparently limited to the extreme southwestern part of the United States and northern Mexico. In the United States extending from southern Texas to southern California and north to Utah and Oklahoma. The variety *plurifasciatus* replaces the typical form in northeastern Colorado northwestern Kansas and Nebraska. About 400 specimens have been examined from the following states: Texas, Oklahoma, Colorado, Nebraska, Utah, New Mexico, Arizona and California; also from Lower California and Mexico.

Agapostemon melliventris var. **plurifasciatus** (Vachal), n. comb.

Agapostemon fasciatus Crawford, Proc. Nebr. Acad. Sci. **7:** 163. 1901.
Halictus (*Agapostemon*) *plurifasciatus* Vachal, Misc. Ent. **11:** 93, 101. 1903. (Proposed for *Halictus* (*Agapostemon*) *fasciatus* Crawford, not *Halictus fasciatus* Nylander.)

Type.—Female and allotype, male (lectotypes selected by Crawford), from Lincoln, Nebraska, in the collection of the United States National Museum.

Distribution.—I have seen specimens of this variety only from Lincoln, Nebraska; Sterling, Colorado; and Clay County, Kansas.

This differs from *melliventris* only in color as given in the key. Since no morphological differences could be found, *plurifasciatus* is considered to be a color variety of *melliventris*.

Agapostemon splendens (Lepeletier)

Halictus splendens Lepeletier, Hist. Nat. Ins. Hymen. **2:** 283, n. 25. 1841.—Cresson, Trans. Amer. Ent. Soc., suppl., p. 293. 1887.—Dalla Torre, Cat. Hymen. **10:** 85. 1896.

Agapostemon aeruginosus Smith, Cat. Hymen. Ins. Brit. Mus. **1:** 86, n. 3. 1853.—Cresson, Trans. Amer. Ent. Soc., suppl., p. 293. 1887.—Dalla Torre, Cat. Hymen. **10:** 97. 1896.

Agapostemon nigricornis Robertson (not Fabricius), Trans. Amer. Ent. Soc. **20:** 147. 1893.—Dalla Torre, Cat. Hymen. **10:** 97. 1896.

Agapostemon splendens Robertson, Trans. Acad. Sci. St. Louis **7:** 328. 1897.—Crawford, Proc. Nebr. Acad. Sci. **7:** 161. 1901.—Howard, Insect Book, pl. 3, fig. 14. 1905.—Graenicher, Ann. Ent. Soc. Amer. **23:** 158, 168. 1930.

Halictus (*Agapostemon*) *aeruginosus* Vachal, Misc. Ent. **11:** 95. 1903.

Halictus (*Agapostemon*) *splendens* Vachal, Misc. Ent. **11:** 95. 1903.

Halictus (*Agapostmeon*) *nigricornis* Vachal, Misc. Ent. **11:** 100. 1903.

Type.—Female. "Carolina." The present location of the type is unknown to the writer. The type of *aeruginosus* is in the British Museum where it was compared by Cockerell and Waterston with specimens of *splendens* and the synonymy confirmed.

Distribution.—Insofar as is known, distributed throughout the eastern and central United States from southern New Hampshire to southern Florida and west to Texas and eastern Colorado. No specimens have been seen from north of the 45th degree of latitude nor west of the 105th meridian. Over 300 specimens have been examined from the following states: New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Maryland, Virginia, North Carolina, Georgia, Florida, Alabama, Michigan, Indiana, Illinois, Iowa, Minnesota, Missouri, Arkansas, Louisiana, Texas, Oklahoma, Colorado, Kansas, Nebraska, and Arizona.

Agapostemon cockerelli Crawford

Agapostemon cockerelli Crawford, Proc. Nebr. Acad. Sci. **7:** 161. 1901.——Cockerell, Pan-Pacific Ent. **3:** 155, female only. 1927.

Agapostemon femoratus Crawford, Proc. Nebr. Acad. Sci. **7:** 162. 1901.—Cockerell, Pan-Pacific Ent. **3:** 157. 1927 (new synonymy).

Agapostemon radiatus Cockerell (not Say), Ent. News **9:** 27. 1898 (new synonymy).

Agapostemon californicus Crawford, Proc. Nebr. Acad. Sci. **7:** 164, female only. 1901 (new synonymy).

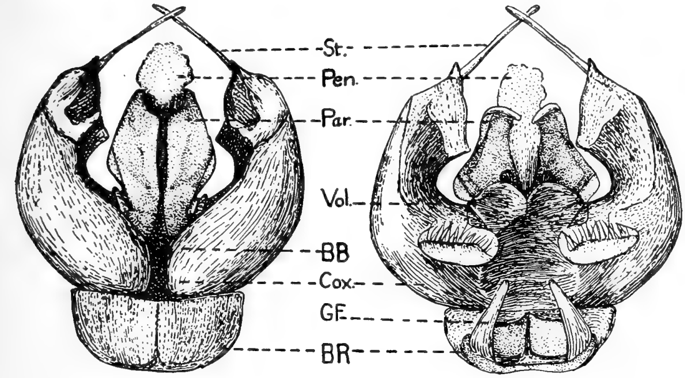
Agapostemon pulcher Robertson (not Smith), Canad. Ent. **34**: 49. 1902 (new synonymy).
? *Nomia cillaba* Cameron, Trans. Amer. Ent. Soc. **28**: 376. 1902 (new synonymy).
Halictus (*Agapostemon*) ? *pulcher* Vachal, Misc. Ent. **11**: 94. 1903.
? *Halictus* (*Agapostemon*) *cockerelli* Vachal, Misc. Ent. **11**: 95. 1903.
Halictus (*Agapostemon*) *femoratus* Vachal, Misc. Ent. **11**: 100. 1903.
? *Agapostemon cillaba* Cockerell, Ann. Mag. Nat. Hist. (8), **4**: 311. 1909.
Agapostemon martini Cockerell, Pan-Pacific Ent. **3**: 153, male only. 1927. (new synonymy).

Type.—Female, holotype, from Mesilla Park, New Mexico, in the collection of the United States National Museum. The type (lectotype, selected by Crawford) of *femoratus* from Moscow, Idaho, and a paratype of *martini* are also in this collection. The type of *cillaba* is in the British Museum. The allotype ("cotype") of *martini* is in the collection of the California Academy of Sciences. Cockerell's designation (1927) of a *type locality* for *femoratus* cannot be considered as a true type fixation, as it was based upon a selection of a locality from literature and not from a study of any of the type series.

Distribution.—Insofar as is known, distributed throughout the western part of North America, west of the 100th meridian, from British Columbia to Mexico. It apparently replaces *radiatus* in the west. Over 300 specimens have been examined from the following states: Texas, Colorado, North Dakota, Montana, Wyoming, Idaho, Utah, New Mexico, Arizona, California, Nevada, and Washington. Material was also seen from Alberta and British Columbia, Canada, and from Mexico.

Agapostemon radiatus (Say)

Halictus radiatus Say, Boston Jour. Nat. Hist. **1**: 394, n. 2. 1837.—Leconte, Writ. Thomas Say **2**: 772, n. 2. 1859.
Halictus tricolor Lepeletier, Hist. Nat. Ins. Hymen. **2**: 289, n. 33. 1841.
Augochlora radiata Smith, Cat. Hymen. Ins. Brit. Mus. **1**: 80, n. 22. 1853.—Dalla Torre, Cat. Hymen. 10: 96, in part. 1896.
? *Agapostemon tricolor* Smith, Cat. Hymen. Ins. Brit. Mus. **1**: 86, n. 2. 1853.
Agapostemon pulchra Smith, Cat. Hymen. Ins. Brit. Mus. **1**: 87, n. 4. 1853. —Cresson, Trans. Amer. Ent. Soc. suppl., p. 293. 1887.
Agapostemon radiatus Cresson, Trans. Amer. Ent. Soc. suppl., p. 293. 1887. —Robertson, Trans. Amer. Ent. Soc. **20**: 147, in part. 1893.—Dalla Torre, Cat. Hymen. **10**: 97. 1896.—Robertson, Trans. Acad. Sci. St. Louis **7**: 327. 1897.—Crawford, Proc. Nebr. Acad. Sci. **7**: 163, in part. 1901.—Howard, Insect Book, pl. 3, fig. 11. 1905.—Lutz, Fieldbook of Insects, pl. xciv. 1918 (1st ed.), 1921 (2d. ed.).
Agapostemon tricolor Robertson, Trans. Amer. Ent. Soc. **20**: 148. 1893.
Agapostemon pulcher Dalla Torre, Cat. Hymen. **10**: 97. 1896.
Halictus (*Agapostemon*) *radiatus* Vachal, Misc. Ent. **11**: 95, 102, 104. 1903.
?*Halictus* (*Agapostemon*) *cockerelli* Vachal, Misc. Ent. **11**: 94. 1903.
Agapostemon sulcatulus Cockerell, Ann. Mag. Nat. Hist. (8), **4**: 25. 1909 (new synonymy).



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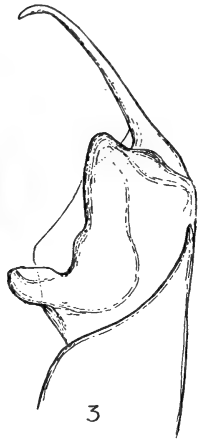

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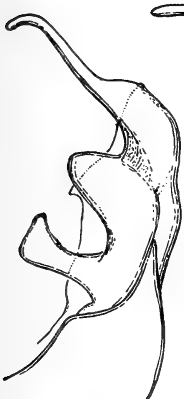

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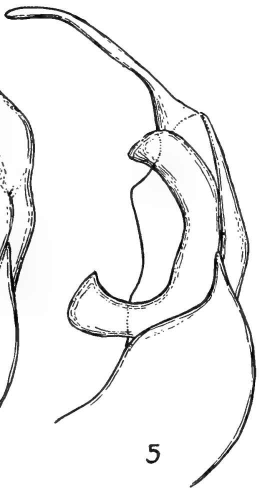

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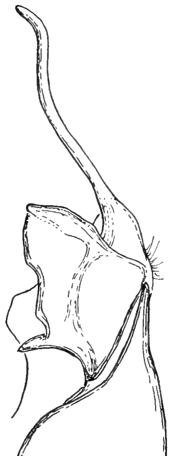

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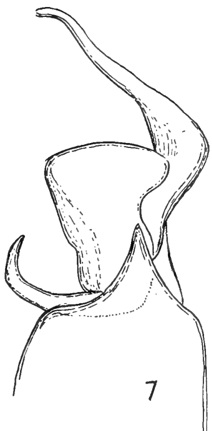

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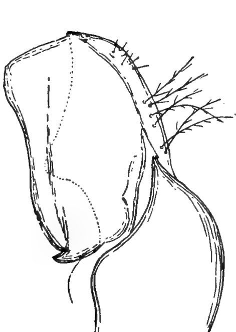

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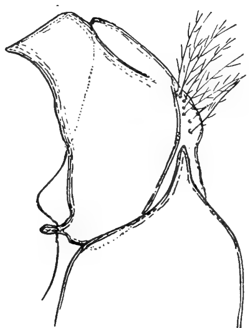

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Fig. 1.—*Agapostemon virescens* (Fabricius). Male genitalia, dorsal view. Fig. 2.—*A. virescens*. Male genitalia, ventral view. BR, Basal Ring; BB, Basal Bridge; GF, Genital Foramen; Cox., Coxopodite; St., Stylus; Vol., Volsella; Par., Paramere; Pen., Penis. Fig. 3.—*A. virescens*. Distal portion of coxopodite, dorsal view. Fig. 4.—*A. angelicus* Cockerell. Distal portion of coxopodite, dorsal view. Fig. 5.—*A. splendens* (Lepeletier). Distal portion of coxopodite, dorsal view. Fig. 6.—*A. coloradius* (Vachal). Distal portion of coxopodite, dorsal view. Fig. 7.—*A. texanus* Cresson. Distal portion of coxopodite, dorsal view. Fig. 8.—*A. melliventris* Cresson. Distal portion of coxopodite, dorsal view. Fig. 9.—*A. radiatus* (Say). Distal portion of coxopodite, dorsal view. Fig. 10.—*A. cockerelli* Crawford. Distal portion of coxopodite, dorsal view. The illustrations were made by Mrs. Eleanor A. Carlin of the Bureau of Entomology and Plant Quarantine.

Type.—Female, Indiana, probably destroyed. The location of the type of *tricolor* is unknown to the writer. The type of *pulchra* is in the British Museum, where it was seen by Cockerell and Waterston and its synonymy confirmed. They felt that the locality "California" on the type of *pulchra* must have been erroneous. The type of *sulcatulus* is in the United States National Museum.

Distribution.—Insofar as is known, distributed throughout the eastern part of the United States, east of the 105th meridian, from Maine to Georgia and from North Dakota to northern Texas. It is apparently replaced in the western states by *cockerelli*. About 650 specimens have been examined from the following states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Alabama, Kentucky, Tennessee, Ohio, Michigan, Indiana, Illinois, Iowa, Minnesota, Wisconsin, Missouri, Louisiana, Texas, Oklahoma, Colorado, Kansas, Nebraska, North Dakota, South Dakota, and New Mexico.

Agapostemon texanus Cresson

Agapostemon texanus Cresson, Trans. Amer. Ent. Soc. **4:** 255, in part. 1872.—Trans. Amer. Eng. Soc. suppl., p. 293. 1887.—Dalla Torre, Cat. Hymen. **10:** 97. 1896.—Robertson, Trans. Acad. Sci. St. Louis **7:** 325. 1897.—Crawford, Proc. Nebr. Acad. Sci. **7:** 160, (? in part). 1901.—Howard, Insect Book, pl. 14, fig. 2. 1905.

Agapostemon texanus subtilior Cockerell, Ent. News **9:** 27. 1898.—Crawford, Proc. Nebr. Acad. Sci. **7:** 160. 1901 (new synonymy).

Agapostemon californicus Crawford, Proc. Nebr. Acad. Sci. **7:** 164, male only. 1901 (new synonymy).

Agapostemon borealis Crawford, Proc. Nebr. Acad. Sci. **7:** 160. 1901.—Cockerell, Pan-Pacific Ent. **3:** 156. 1927 (new synonymy).

Halictus (*Agapostemon*) *borealis* Vachal, Misc. Ent. **11:** 94. 1903.

Halictus (*Agapostemon*) *texanus* Vachal, Misc. Ent. **11:** 94. 1903.

Halictus (*Agapostemon*) *subtilior* Vachal, Misc. Ent. **11:** 95, 102, 104. 1903.

Agapostemon texanus iowensis Cockerell, Ann. Mag. Nat. Hist. (8), **5:** 363. 1910 (new synonymy).

Agapostemon texanus vandykei Cockerell, Proc. Calif. Acad. Sci. **14:** 191. 1925 (new synonymy).

Agapostemon cockerelli Cockerell, not Crawford, Pan-Pacific Ent., **3:** 155, male only. 1927 (new synonymy).

Agapostemon vandykei Cockerell, Pan-Pacific Ent. **3:** 155. 1927.

Type.—Female, lectotype, from Texas, in the collection of the Academy of Natural Sciences of Philadelphia. The type of *subtilior* is probably in Cockerell's collection. The type of *borealis* is in the Academy of Natural Sciences of Philadelphia. The type of *iowensis* and the lectotype (selected by Crawford) of *californicus* are in the United States National Museum. The type of *vandykei* is in the collection of the California Academy of Sciences.

Distribution.—Insofar as is known, distributed throughout the United

States from coast to coast north of the 40th degree of latitude, extending southward along the Appalachian Mountains to North Carolina, along the Rocky Mountains to southern Texas and Mexico, and along the Pacific Coast Ranges to southern California. About 1000 specimens have been examined from the following states: New Hampshire, Connecticut, New York, Pennsylvania, North Carolina, Michigan, Indiana, Illinois, Iowa, Minnesota, Wisconsin, Louisiana, Texas, Oklahoma, Colorado, Kansas, Nebraska, North Dakota, South Dakota, Montana, Wyoming, Idaho, Utah, New Mexico, Arizona, California, Oregon, Nevada, and Washington.

Agapostemon angelicus Cockerell

Agapostemon angelicus Cockerell, Proc. Calif. Acad. Sci. **12**: 537. 1924.—Pan-Pacific Ent. **3**: 156. 1927.
Agapostemon texanus Cresson, Trans. Amer. Ent. Soc. **4**: 255, in part. 1872.—? Authors, in part (new synonymy).
Halictus (*Agapostemon*) *texanus* Vachal, Misc. Ent. **11**: 94, ? in part. 1903.

Type.—Female, Pond Island, Bay, Angel de la Guarda Island, in the collection of the California Academy of Sciences.

Distribution.—Apparently limited to the southern Rocky Mountain region from southern Texas to North Dakota and Idaho and along the Pacific Coast from southern California to the 40th degree of latitude. Over 400 specimens have been examined from the following states: Texas, Colorado, Kansas, Nebraska, North Dakota, South Dakota, Wyoming, Idaho, Utah, New Mexico, Arizona, and California.

This species is very similar to *texanus* and has undoubtedly been confused with it in most collections. The females may be distinguished by the sculpturing of the dorsal surface of the propodeum; the males, by the markings on the hind legs.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

267TH MEETING

The 267th regular meeting was held in the assembly hall of the Cosmos Club, October 1, 1935, President W. W. DIEHL presiding, attendance 70.

Notes and reviews.—J. B. S. NORTON reviewed the recently issued volume 2 of Hutchinson's *The families of flowering plants.*

Program.—W. C. LOWDERMILK: *Notes on the Third International Congress of Soil Science, Oxford, July 30–Aug. 7, 1935.*

CHARLES DRECHSLER: *Notes on the Deutsche Botanische Gesellschaft, Cologne, Aug. 28–Sept. 2, 1935.*

Reports on the Sixth International Botanical Congress, at Amsterdam, Sept. 1–7 were made as follows: Phytopathology by CHARLOTTE ELLIOTT; physiology by A. M. HURD-KARRER; taxonomy by DORIS HAYES; mycology and bacteriology by CHARLES THOM.

268TH MEETING

The 268th regular meeting was held in the assembly hall of the Cosmos Club, November 5, 1935, President W. W. DIEHL presiding, attendance 92. G. H. COLLINGWOOD, S. L. EMSWELLER, JEWELL G. GLASS, MAX M. HOOVER, M. T. JENKINS and HAROLD H. SMITH were elected to membership.

Notes and reviews.—ROLAND W. BROWN reported the finding of a specimen of *Hamamelis* in Pennsylvania with rose-colored petals. This form has been previously mentioned by Sargent.

M. B. WAITE discussed the competitive effects of the outdoor flower business upon the cut-flower trade, as well as certain aspects of autumnal coloration.

H. B. HUMPHREY reported on the differences in leaf-fall and coloration between the District and Maryland.

Program.—L. W. KEPHART: *The place of botany in weed research.*

J. A. MARTIN: *The classification of American wheats.* A review of Technical Bulletin 459 of the United States Department of Agriculture by J. A. Clark and B. B. Bayles, with a further discussion of the work of the Division of Cereal Crops and Diseases of the Bureau of Plant Industry along the same lines.

H. B. HUMPHREY: *The epiphytotic of black stem rust in 1935.* Discussed by Messrs. CLARK, HASKELL, LEIGHTY, LUDWIG and WAITE.

269TH MEETING

The 269th meeting was held in the assembly hall of the Cosmos Club, December 3, 1935, President W. W. DIEHL presiding, attendance 97. IRVING W. DIX and JOSEPH J. STROUP were elected to membership.

Program.—W. W. DIEHL: *An outline of mycogeography.* Distribution of fungi over the earth is only partly in conformity with the better known distribution of seed plants in life zones,—and then chiefly when that is necessitated by a restricted obligate parasitism or saprophytism. There are other provinces of fungus distribution made up of endemics which overlap these life-zones. Recognition of endemic provinces and of provinces conforming to life-zones is complicated by the great number of species of fungi which

are cosmopolitan in distribution. This cosmopolitanism is being increased through the influence of man in aiding many species to surmount the barriers which formerly restricted their distribution. (*Author's abstract.*)

35TH ANNUAL MEETING

The 35th annual meeting was held immediately following the adjournment of the 269th meeting. The recording secretary reported that 34 new members had been elected during the past year, bringing the membership of the society to 249, of whom 243 were active and 6 honorary. Two members passed away during the year, DAVID GRIFFITHS and W. W. EGGLESTON. A biographical sketch of the former was prepared by H. B. HUMPHREY and read by E. O. WOOTEN who gave in addition personal recollections of the deceased. A. B. CLAWSON read an obituary of Mr. Eggleston. Four members who had retired from professional work during the course of the year were elected to honorary membership, LESTER H. DEWEY, C. L. SHEAR, WILLIAM STUART and MERTON B. WAITE.

The following officers were elected to serve for the ensuing year: President, JOHN W. ROBERTS; Vice-President, CHARLES F. SWINGLE; Recording secretary; G. F. GRAVATT; Corresponding secretary, ALICE ANDERSEN; Treasurer, NELLIE W. NANCE. CHARLES DRECHSLER was nominated as vice-president of the Washington Academy of Sciences representing the Botanical Society of Washington.

CHARLES F. SWINGLE, *Recording Secretary*

Obituary

Albert Spear Hitchcock, principal botanist in charge of systematic agrostology, Bureau of Plant Industry, U. S. Department of Agriculture, died on shipboard, December 16, 1935, while en route home from the 6th International Botanical Congress at Amsterdam and a period of study in European herbaria. Doctor Hitchcock was born September 4, 1856, at Owasso, Michigan. He received the degree of Bachelor of Science in Agriculture from Iowa State College in 1884, and the Master's Degree in 1886. The same institution awarded the doctorate in science in 1920. Following a brief experience as an assistant in chemistry, he turned definitely to a botanical career as an instructor in botany at Iowa College for the years 1886–89. After spending the years 1889–91 as a botanical assistant at the Missouri Botanical Garden he became Professor of Botany at the Kansas Agricultural College, remaining in that position until 1901 when he was called to the Bureau of Plant Industry, at Washington, as Assistant Agrostologist. Merited promotion brought him the title of Agrostologist in 1905, Senior Botanist in charge of systematic agrostology in 1924 and Principal Botanist in 1928. For many years he was Custodian of Grasses of the U. S. National Herbarium, Smithsonian Institution. During 1919 he was a member of the National Research Council.

Doctor Hitchcock was not merely an herbarium botanist, but had travelled and botanized in the field to an extent equalled by few botanists. His travels in quest of grasses and botanical information had taken him into all the states of this country, Canada, including the Arctic regions, Labrador, Alaska, the West Indies, South America throughout its length, Europe, Hawaii, the Philippine Islands, China, Indo-China, and Japan. His numerous and authoritative publications have covered the field of systematic agrostology, culminating in the recently issued monographic masterpiece, *Manual of the grasses of the United States.*

Doctor Hitchcock was president of the Botanical Society of America in 1914. He was also a member of the Washington Academy of Sciences, the Botanical Society of Washington (President, 1916), the Biological Society of Washington (President, 1923), the Washington Biologists' Field Club, and the Kansas Academy of Sciences.

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Vol. 26 March 15, 1936 No 3

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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JOURNAL
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MEDICINE.—*Comings and goings of epidemics.*[1] GEORGE W. McCOY, M.D., National Institute of Health.

Although the study of disease as manifested in the individual patient is one of the most interesting vocations for those whose tastes run along such lines, of far greater interest, and obviously of greater importance, is the study of disease as it affects a group, or groups, of people. The group may be small or it may be so large as to include all or most of the race.

Everyone knows that the manifestations of the same disease differ with individuals and an acquaintance with this variance is often the secret in making correct diagnoses. In a similar manner, outbreaks of disease at different times and in different places show variations, the recognition of which leads to accurate epidemiological diagnoses. I shall endeavor to illustrate some of the problems in epidemic diseases that have been solved and to consider others that remain to be solved. By observation and study of disease as manifested in a population it is often possible to learn the factors governing the prevalence of the particular disease and, this learned, to take effective measures of prevention or suppression.

Epidemic is defined as "common to, or affecting at the same time, a large number in a community." Generally, the term is used in reference to communicable diseases but we have it applied to such miscellaneous non-medical occurrences as traffic accidents and bank failures.

In this presentation, I have had occasion to consult several standard works, particularly the *Bible,* Hirsch's *Handbook of Geographic and Historical Pathology,* Delmage's work entitled *The Nation's Health,* and, finally, Vaughan's *Epidemiology and Public Health.* The latter, an exceedingly valuable work and especially useful to anyone interested in the history of epidemics, was the last important literary contribution of the late Dr. Victor C. Vaughan, a very distinguished physician, long a resident of Washington and a member of the Cosmos

[1] Address of the retiring president of the Washington Academy of Sciences delivered January 16, 1936. Received January 17, 1936.

Club. I have drawn freely on all of these works and here make acknowledgment of these sources of information.

Delmage (p. 65) states that the principal diseases prevalent during the middle ages were "famine pestilences, plague, leprosy, ergotism, scurvy, dancing mania, syphilis, malaria and various skin diseases." Omitting skin diseases as being too indefinite for comparison, only two of the remaining diseases he mentions are of great importance today, malaria and syphilis. I am not informed as to the exact nature of the "dancing mania" of those days but I have a suspicion that it is still on the decline after a recrudescence of the post war period and the era of national prohibition. Delmage makes no mention of any of the diseases we recognize as heading the list of causes of death at the present time—cancer, heart disease, pneumonia, and tuberculosis—though doubtless they were just as prevalent then as now, but on account of the greater prevalence of other diseases did not earn for themselves a prominent place as major scourges.

Epidemics may be due to unusual and rarely occurring combinations of circumstances. For instance, a consignment of psittacine birds is shipped from an aviary in California to an eastern department store; the birds are displayed and admired; some are purchased and taken home; then, perhaps ten days later, a few of the employees of the store, admirers, or purchasers of the birds become ill with a peculiar type of pneumonia that puzzles attending physicians. These cases are scattered in various parts of the community. At first sight there is no suspicion as to relationship between cases. Then, quite possibly by chance, it develops that the illness began a week or ten days after the arrival of the birds in the store or after bringing the new bird into the home—the bird, or birds, perhaps sickening in the meantime. The solution of the epidemic from that time forward becomes a routine matter for the health department staff. Perhaps many similar outbreaks of this type come and go without being recognized.

An excellent example of how a disease ordinarily not known to prevail in epidemic form may, by some peculiar combination of circumstances, become epidemic is to be found in the outbreak of amebic dysentery centering in Chicago in the summer and fall of 1933. Here was a disease which the very elect among special students in the field had said never was, and indeed never could be, epidemic; and we all subscribed to the dictum. Then came one of the unforeseen, and humanly speaking unforeseeable, tragedies in public health. Through peculiar circumstances there occurred an opportunity for

the drinking water supplies of two hotels in Chicago to become infected with the protozoal organism causing one of the types of dysentery. There resulted about 1200 reported cases, scattered all over the country, and of these about 100 died. There is good reason to believe that the total number of cases and deaths exceeded this considerably but it was not practicable to secure full reporting. It took quite a while even for those of the medical profession who were especially interested in the problem to admit that there could be, and was, an epidemic of this type of disease. In addition to being the first widespread epidemic of this disease in a civil population it made us all conscious of the possibility of impure water being involved in the causation of the disease as it ordinarily occurs.

To illustrate that our concept of epidemics need not be limited to communicable diseases let me briefly discuss scurvy. We first hear of it in the 13th century in connection with the Crusaders, although doubtless it existed long before that time. According to Vaughan, Joinville (1260, p. 37) wrote: "The barbers were forced to cut away large pieces of flesh from the gums, to enable their patient to eat. It was pitiful to hear the cries and groans of those on whom this operation was performing; they seemed like the cries of women in labor." The disease was a special scourge of navigators and explorers. Scarcely an expedition but suffered cruelly from the ravages of what we now know to be an easily preventable disease. Thus, Vasco da Gama's voyage around the Cape of Good Hope, in 1497, resulted in the loss of about two-thirds of the men, mostly from scurvy. Magellan's crews on the voyage around the world, begun in 1519, the first in history, were harrassed by the disease. Cartier's expedition to Canada, 1535, has yielded us a clinical description of such noteworthy fidelity that I forbear reading it to you so gruesome are the details. Apparently the disease was previously unknown to Cartier and his medical staff but they found that the juice of the bark and leaves of a certain spruce was an effective remedy, a clear hint as to the relation to diet now so well established. As early as 1564, orange juice was prescribed in the treatment of scurvy, the first mention of citrus fruits in connection with the disease.

Lind, a British naval surgeon, whose view was about 150 years in advance of his time, carried out (about 1750) what we would now call a feeding experiment to determine the diet most effective in the treatment of scurvy, but (and it shows that bureaucracy was pretty much the same then as now) it took another 50 years for the British Admiralty to take the necessary administrative action to profit by

his findings. Lind added nothing essential to what had been known for 200 years, but he was a true scientist and furnished proof of what up to that time had been only belief.

Captain Cook, in his voyage around the world from 1772–1775, lost not a man. He carried an ample supply of sauerkraut. Take your choice, sauerkraut or scurvy! The sailor of that day was not fastidious and had no difficulty in making the choice. To show you that I have a little historical data of my own, and lest someone criticize the accuracy of my statement about Cook's voyage, I want to say that I know quite well that on a later voyage, 1779, Captain Cook was killed by the natives of Hawaii. I have visited the place where he is said to have been killed, and, in order to show still further my first hand information on this subject, let me say that I have visited the monument erected to Captain Cook's memory by the British government, and am aware of the fact that every few years a British cruiser is sent to Hawaii to "police up" the surroundings of the monument.

Yet in spite of these experiences, several years after Captain Cook's voyage, a 10 weeks' cruise of the British fleet in the Bay of Biscay resulted in 2400 cases of scurvy—so slow is official authority to recognize and adopt new measures. This disease has played an important role in land military operations as well as at sea, prolonged sieges always bringing it to the fore among the besieged and besiegers, always, of course, due to the same essential cause, deficiency in diet. This disease, which at one time was so prevalent, affecting civil as well as naval and military populations, has now become practically unknown in the civilized world save in what we might call the rudimentary form that occurs among infants.

"Sweating sickness" is the only disease entity on record that seems to have vanished completely centuries ago. According to Delmage, this disease prevailed in England for a period of about 65 years in the latter part of the 15th and the early part of the 16th centuries. According to the same author, "it was characterized by a very sudden onset, acute symptoms, and profuse sweating" or, as a contemporary observer puts it, by a "grete swetyng and stynking and a contynual thirst with a grete hete and headache." It seems to have sought out by preference the highly placed. Thus, we find mentioned as victims two lords mayor and four aldermen of London; also Wolsey, the Venetian ambassador, and Anne Boleyn. The King, Henry VIII, appears to have escaped the affliction by keeping on the move. It sounds like the history of an infectious disease but against this is evidence that it produced no immunity as repeated attacks in the same individual

are referred to. This, of course, does not absolutely exclude the infectious nature. The disease invaded the Continent of Europe and is said to have broken up the Diet of Worms in 1521, perhaps fortunately for intellectual progress and the liberalization of the minds of men. Medical historians are not able to identify this epidemic visitation with any earlier or later outbreak of any sort.

Having given an example of a disease that has disappeared, let me now give you examples of new, or relatively new, diseases—though it is doubtful whether any disease is really new; often it is new only in the sense that it is newly recognized. We usually regard tularaemia as a new disease since not even the name was known more than a decade ago, but my colleague, Doctor Francis, who has contributed so much to the knowledge of the disease, has unearthed cases that occurred long before we had any scientific knowledge of the infection, which, as you know, usually is derived from dressing infected animals, nearly always rabbits. A friend with a much better knowledge of the Bible than I have calls my attention to the fact that among the ancient Hebrews the rabbit (coney) was forbidden as food, and argues that this prohibition could come only from a knowledge of a disease derived from the forbidden food (Leviticus, chapter 11, verse 5). The injunction in the 8th verse of the same chapter reads: "Of their flesh ye shall not eat and their carcasses shall ye not touch."

This disease, not communicable from person to person, would hardly have been recognized as epidemic before the days of bacteriology and for practical purposes may be regarded as a newcomer but it is recognized now in nearly every State in the Union and in several foreign countries.

For a century or more physicians in the Mediterranean area have recognized a disease of long duration and peculiar clinical characteristics which many years ago was found to be contracted usually by the drinking of goat's milk. So firmly established was the relation between the goat and the sick man that no one thought of Mediterranean fever, undulant fever, or Malta fever, as it was variously known, save in association with possible sources of infection among goats. In this country, the occasional case recognized was traceable to goats and the distribution was limited almost entirely to the southwestern part of the country where the goats were known to be infected. Then came the brilliant work of Miss Evans and others, who showed that undulant fever might be derived from cattle infected with contagious abortion. A new disease was created, or discovered, almost overnight. Cases began to be recognized nearly everywhere in the United States

and in many other parts of the world. Whether the many cases now reported by physicians really represent a new disease in this country or whether similar cases have been with us a long time but have not been correctly diagnosed, can not be answered in a satisfactory manner. There would seem to be valid arguments for both views. For practical purposes, we may regard the infection derived from cattle as a new disease in this country, and indeed this holds good for the temperate parts of the world generally.

Among the epidemic diseases relatively new to the race, none is more interesting than the group affecting the nervous system. I shall discuss briefly two of these.

Cerebrospinal fever, perhaps more often called cerebrospinal, or epidemic, meningitis, appears to have been quite unknown until 1805, when it was reported in Switzerland. Within a few years it has been identified in many places in Europe and America. This is a disease of very pronounced manifestations in the sick individual and of marked peculiarities in its epidemic qualities. The great Osler thought that the keen medical minds of the 17th and 18th centuries would not have overlooked it, and said: "In cerebrospinal fever we may be witnessing the struggle of a new disease to win a place among the great epidemics of the world."

A year after the occurrence of the Geneva outbreak (the first reported) the disease was discovered, independently, in New England, and from that time down to the present most countries have had anywhere from a few scattered cases to disastrous epidemics. For a long time after the disease became established as an entity quite apart in origin from any other disease there was much questioning as to whether or not it was contagious. For one of the most convincing experiences in this connection let me quote from Vaughan:

> For many years Boudin stood almost alone not only among French observers, but among those in all parts of the world, in contending for the infectious nature of this disease. One of the most convincing instances cited by Boudin in his contention for the infectious nature of the disease is the experience of the 18th infantry (of the French army). Cerebrospinal meningitis had been epidemic among the civil population in the Department of Landes in the Lower Pyrenees adjacent to Spain for some years prior to 1836. This regiment was stationed at Bayonne in this part of France and was in part recruited from the population of this section. Cerebrospinal meningitis appeared in two garrisons in the Department of Landes, Bayonne and Dax, in which this regiment was quartered. The regiment moved first to Bordeaux and then to Rochefort, but the disease not only continued with the regiment, but spread to some slight extent outside the garrison, especially at Rochefort where the inmates of a prison became involved. This regiment was stationed at Bayonne in 1836. It left Rochefort at the end of

1838 and went to Versailles. In February, 1839, six men of the regiment, all occupying the same room, came down with cerebrospinal meningitis at intervals of a few days. At Versailles the disease extended to other regiments, but out of a total of 160 cases at that place 116 occurred in the Eighteenth, while the remainder were distributed through four other infantry regiments and three troops of cavalry. The Eighteenth regiment was subsequently transferred to Chartres and later distributed to Metz, Strasbourg, Nancy, Schlestadt, and Colmar, in all of which places cerebrospinal meningitis not only continued in the Eighteenth Infantry, but especially attacked the recruits to this regiment, and spread to other military organizations with which the Eighteenth came in contact and, in some places, to the civil population. There is some reason for believing, though the proof is not clear, that the disease was spread by troops from the Department of Landes towards the Mediterranean. From 1841 to 1849 nearly every garrison in France from Lille in the North to Marseilles in the South and from Brest on the Atlantic Coast to Strasbourg on the Rhine reported small epidemics of this disease. Not only was this true, but cerebrospinal meningitis was carried by French soldiers to Algerian garrisons.

Finally, in this group, comes epidemic encephalitis, the history of which is recent. I think there is much question as to the identity of various outbreaks of the encephalitis group of diseases. For practical purposes we may consider the outbreak in St. Louis in 1933 as a unique event in medical history. Coming apparently from nowhere, progressing for three months, and vanishing as mysteriously as it began, the disease could not be identified beyond doubt with any previously recognized clinical and epidemiological entity. It attacked about 1,000 people and took the lives of about one-fifth of that number. It was tentatively grouped, by those studying it, with an epidemic condition that has been prevailing in Japan occasionally for perhaps half a century, but there were certain features of dissimilarity which had to be admitted.

One of the most important of the questions we are called upon to consider is this: To what extent are man's efforts, aimed directly at the control and suppression of disease, effective? I am compelled to confess that those of us concerned especially in preventive medicine are likely to claim too much. Often we have failed to take into account that epidemics may come and go without much regard for what we do or fail to do. There is coming into existence a more sane attitude on this point and we find ourselves adopting a more critical attitude towards our efforts at disease prevention, and when we attempt to appraise the results of our own efforts we take into account as well the operation of natural causes which we are not able to control. Let me give you as an example of a disease in the control of which I think there is no question but that purposeful measures have

been highly successful. I have in mind yellow fever. Many of us remember when it occurred all too frequently in epidemic form in the United States, and was practically always present in tropical America. Then came the brilliant studies of the army commission made up of Reed, Carroll, Lazaer, and Agramonte, work which showed that in a certain species of mosquito lay the secret of the spread of the disease. This was followed by the work of the administrative authorities who showed that by attacking the mosquito, attacking it especially at the most vulnerable point, the breeding places, the chain of events leading to the epidemic could be broken and the disease prevented or promptly eliminated if it already had gained a foothold. Here was a disease, the elimination of which from the world seemed readily feasible, and one of the great international public health agencies set for itself the task of freeing the world of yellow fever. The task was begun perhaps 20 years ago and it may be said without doubt that great good has been accomplished but it may be said, equally without doubt, that the goal appears no nearer now than when the work was begun. True, the disease has been readily suppressed in the important ports and other cities of the world but it has been found to lurk in the more remote places, places in which the attack on it is much more difficult. It has been found, too, that more than one species of mosquito may carry the disease, and finally, that atypical clinical cases may serve as foci of spread. In spite of these facts, let me say that on the whole the results of the warfare on yellow fever have been brilliant, though falling short of our expectations.

Now let me give you an example of a disease in which the problem of elimination seemed to be even more easy of solution than that of yellow fever. I refer to pellagra, a nutritional, or dietary, deficiency disease very prevalent in our Southern States and in certain other parts of the world. The brilliant experimental work of Goldberger and his associates showed that the only thing needed to prevent the development of pellagra in an individual and even to cure it if already developed was a suitable diet. When it came to practical application of the experimental findings on a large scale, difficulties were encountered. It was not, and is not, easy to modify the dietary customs of large groups of people and, of course, the economic factor usually is the predominant one since a "suitable" diet costs more than the relatively inexpensive diet which often leads to the development of pellagra. So we still have a disgraceful amount of the disease, if we think in terms of how much we know about it and how easy is its prevention, but probably we have no more than is inherent in dietary

customs and the economic status of the parts of the world in which pellagra prevails.

In this day when smallpox is so rare that many physicians go through a busy professional career without seeing a case, it is difficult to credit the statement that there was a time, not so long ago, when English employers of domestic servants made it a condition for acceptance into service that the prospective employee should have had smallpox in the natural fashion. Perhaps the prevalence of no other disease, has been so much influenced by direct attempts at control as this one. Contrast the experience of Boston, 1721, when about 6,000 were attacked in a population of 10,500 with the experience of today when the disease is so readily controlled by vaccination that it has ceased to be a major scourge. While not yielding to anyone in honoring Jenner for having given us vaccination, I must remind you that before his day there was a crude method of prevention of smallpox based on the same principles used by Jenner. Purposeful inoculation of smallpox itself usually gives rise to a mild form of the disease which protects against an attack acquired in the natural way. This method antedates the Christian era.

It is significant of the changed attitude of the population as to its social responsibility that inoculation, the precursor of vaccination, was chiefly practiced among the well-to-do, that is among those who could pay for it. Nowadays a child has a poor chance to escape vaccination, be he poor or rich.

I will now discuss briefly two diseases that have become relatively rare, due, in my opinion, not so much to man's direct attempts to control them but to influences concomitant with the advance of civilization.

The "black death" of the 14th Century usually is identified with plague of more recent times, but the accounts that have come down to us give no sure grounds for insisting on the identical nature of the two. When we read of the disease in those days being so virulent as to infect swine (animals never attacked by plague as we know it), our skepticism seems well founded. On the other hand, some of the clinical descriptions seem to leave little choice but to call the disease plague. Whatever the nature of that early epidemic may have been there is no doubt as to its destructiveness. Thus, three out of every 5 in Florence are said to have died; in Italy as a whole and, indeed, in England, half of the population of that day died from this disease. This outbreak gave us one notable, crude advance in preventive medicine, the genesis of quarantine systems. In the early form it con-

sisted of arbitrary detention of ships at ports still uninfected for 40 days after their arrival from an infected country. I have said it was crude, but no more crude than the measures taken by some governmental authorities within the past few months in connection with the spread of the epidemic of poliomyelitis which occurred last summer, and it is to be said that the earlier attempts to quarantine and the later ones are about equally ineffective.

The London plague of 1665 is said to have killed 98,000 among a population of one-half million. We have had what we consider pretty bad outbreaks in modern times (notably British India) but there is nothing to even remotely approximate the London experience. Happily, it is now recognized that plague will not become a menace in any modern community. We owe this fortunate state of affairs not so much to any intensive improvement in sanitation but rather to changes in our environment which have put us on less friendly terms with the rodent population. It is suggested that the complete obliteration of plague in England was due to the fact that the black house rat, which came in close contact with man, was driven out in the 18th century by the brown rat, which ordinarily is not found in such close association with man.

I have spoken of the relative freedom the world now enjoys from plague but I might possibly be charged with too much optimism did I fail to tell you that once before, for a period of about 7 centuries, England remained free from plague, that is, between the Justinian plague of the 7th century and the other outbreak of the same disease known as the "black death" in the 14th century.

The fact that leprosy is the only definite clinical condition mentioned in the Bible, and the space given to it there, indicates how important a problem it was in those days. This disease was so prevalent in Europe in the Middle Ages that leprosy isolation hospitals were numbered by the thousands while today in the whole civilized world they may be numbered only as a few dozen. It may be stated here (though not necessary to the present discussion) that there is good authority for the statement that the leprosy hospital often formed the nucleus of the general hospital after the former ceased to be used for the special purpose for which it was constructed, and, further, that many of the great European hospitals of today go back to such humble origin.

It is interesting to observe how the ideas of the race as to the cause of leprosy have varied from time to time. Thus, in biblical times the injunction for sanitary administrative control such as Moses laid

down spell out a clear recognition of the fact that the disease was considered communicable, or, as often stated, that "leprosy begets leprosy." Then came a period of several centuries in which it was looked upon as not communicable. By the latter part of the middle ages hard experience had forced into the minds of man the fact that the disease did spread, and those who suffered from it were a menace to the health of those around them, hence the large number of asylums referred to as having existed at that period. This view prevailed until well into the 19th century. In 1867, the Royal College of Physicians (London) declared leprosy to be non-contagious. A little later came the studies of the great Norwegian, Hansen, who established the infectious and communicable nature of the malady, a fact so generally accepted at the present time that we have difficulty in appreciating that for long periods the minds of men rejected the communicability of the disease. The facts at hand do not justify any other conclusion as to the spread and decline of leprosy at different periods and in different countries. I venture the suggestion that leprosy is to be regarded as an epidemic disease which rises and falls due to circumstances beyond our knowledge and largely beyond our control. It differs from other infectious diseases, however, in that the cycle covers one to several centuries whereas with most other epidemics the cycle is completed in a few weeks, or a few months at the outside. I can make this suggestion with much safety to my professional reputation since no one can disprove it today, and it will take several centuries to prove it if it chances to be well founded.

In conclusion, I will mention problems presented by an epidemic disease that has not been influenced in respect to prevalence either by purposely directed efforts or by the onward march of civilization and progress.

I am a member of a group charged with certain responsibilities in connection with researches on influenza and other respiratory diseases and rarely do we meet without some discussion, often disputes, as to just what influenza is. The questions most frequently asked, and never answered, are: 1. Are the various pandemics that occur at intervals of 20–30 years due to the same virus? Tentatively, the answer is yes. 2. A much more difficult question is as to the inter-epidemic prevalence of the disease. Are these relatively mild outbreaks due to the same virus that causes the pandemic outbreaks or are they due to different viruses? There is no agreement on this point and we must keep an open mind. Until we have some new method of approach enabling us to identify the causative agent with certainty,

speculation is rather futile. In the meantime, the term "influenza" is likely to continue to be used by physicians and laymen for miscellaneous respiratory disorders to which no other diagnosis is readily applicable. Perhaps what I have just said may be made somewhat clearer by the explanation that the diagnosis of true influenza is based more on the characteristics of the epidemic prevailing at the time than on the manifestations in the individual patient. In 1918, one could say with much confidence that any group of patients had influenza but in 1936 any small group or any single patient is not so certainly disposed of from the point of view of diagnosis. In the epidemics, particularly in the pandemics, the outstanding features are widespread prevalence, high incidence, and lack of preference for any age, sex, social or racial group. It is true there are some variations in the attack rates for different age groups in different epidemics; nevertheless, what I have said is substantially correct. Another feature is the general progress of the disease from east to west. Always there is an interval of a few months between the appearance of the disease in, let us say, Moscow and in San Francisco.

The outbreak of 1918 and that of 1920 were the first to be studied by modern methods and yet I fear that the intensive and extensive studies carried on then, and later, have not resulted in any really helpful information so far as treatment of the disease and control of outbreaks are concerned. We did learn from the few experiences that strict quarantine measures would protect well isolated communities but that this was impracticable on a large scale. It was impracticable even for military camps, where requirements designed to protect could be made more rigid than for a civil community. Some communities, in attempting to control the disease, did things that in retrospect appear amusing. One west coast city required everyone to wear gauze masks over the mouth and nose, closed the churches, but, for readily understood reasons, did not close the saloons. Perhaps a story is worth telling to illustrate the situation. It chanced that the decline of influenza was about synchronous with the Armistice celebration in San Francisco and a physician friend of mine was accosted on the streets in the early morning of Armistice Day by a bibulous individual celebrating in true San Francisco style, and that means, to say the least, with enthusiasm. The bibulous individual was laughing and very voluble and my friend remarked to him that, of course, winning the war was wonderful but it scarcely seemed to justify the extreme kind of celebration in which he was indulging. The tipsy one replied hilariously that he was not celebrating the end

of the war but how wonderful it was to have a city with every church closed, every saloon open, and every woman muzzled!

[The speaker concluded his remarks by showing a series of slides depicting events and phenomena associated with past epidemics. Ed.]

BOTANY.—*Rock midget, a new species of* Mimulus *from Death Valley, California.*[1] FREDERICK V. COVILLE, U. S. National Herbarium.

The plants of Death Valley, California, are of special interest because they exist under conditions of extreme heat and aridity. This interest has become much more widespread since Death Valley was made a national monument, in 1933. More than 42,000 persons visited the valley in 1935. My own *Botany of the Death Valley Expedition*, published in 1893, is still the principal work of reference on the plants of Death Valley. In the process of preparing a new account of these plants, several species new to science have been found and published. Another is described in the present paper. Its specific standing has been confirmed by Dr. Adele Lewis Grant, author of *A Monograph of the Genus Mimulus*, 1924. The illustration (Fig. 1) is from a photograph made by Mr. B. Anthony Stewart, of the National Geographic Society. To him and to the Society I am indebted for the privilege of publishing it.

Mimulus rupicola Coville & Grant, sp. nov.

Annuus, Mimulo tricolori affinis, sed corollis brevioribus et pallidioribus, foliorum caulinorum apicibus et calycium lobis acutissimis, nec obtusis; pedicellis fructiferis recurvatis, deinde porrecte curvatis, nec rectis; capsulis falcatis, acutis, puberulis, a sutura convexa mox dehiscentibus, nec, modo M. tricoloris, ovatis vel oblongis, obtusis, glabris, et tardissime dehiscentibus. Fissuras rupium calcariarum montibus eremis Vallis Mortis, nec, ut M. tricolor, locos aquosos exsiccantes Californiae intramontanae, habitat.

Plant belonging to the section Oenoe, annual, 2 to 15 cm in height, beginning to flower when very young and with only a few leaves, all basal, the plants later becoming much branched from the base; stems densely glandular-pubescent to glandular-villous; basal leaves 2 to 6 cm long, 2 to 10 mm wide, the elliptical-lanceolate to linear-lanceolate or oblanceolate blades narrowed at the apex to a usually blunt point, and tapering very gradually at the base into a petiole often as long as the blade and margined for most of its length, entire or rarely with an irregular tooth, glandular-pubescent, often rather sparingly, the margins and petiole often glandular-villous; stem leaves opposite, up to 15 mm in width, elliptical-oblong, acuminate to a usually very acute tip, narrowed below to a short margined petiole, glandular-pubescent, usually densely so, and often glandular-villous; flowers occurring singly in the axils of the leaves; pedicels glandular-hairy,

[1] Received December 21, 1935.

at first commonly 1.5 to 2 mm long, and straight, in fruit sometimes increasing in length to 4 mm and bent sharply downward and to one side at the base, then, above, forward and outward, twisted half way round, becoming hard and woody and solidly attached to the rigid stem and to the base of the capsule; calyx usually 10 to 12 mm long, sometimes 13 mm, in depauperate plants sometimes only 6 mm long, plicate, scarious below the sinuses, glandular-pubescent, and sometimes with a few longer, soft, gland-tipped

Rock midget, *Mimulus rupicola* Coville & Grant, sp. nov. Natural size.

hairs, the throat oblique, the teeth very unequal, ciliate, triangular-ovate to triangular-lanceolate, attenuate to slender, often filiform, very acute tips, the posterior tooth 2 to 4 mm long, about twice the length of the others, reaching 2.5 to 4 mm farther than the two anterior teeth; corolla about two and a half times the length of the calyx, usually 20 to 30 mm long, in depauperate plants sometimes only 15 mm, the tube, throat, and lower part of the lobes sparingly glandular-puberulent, tube slender, yellow, about twice as long as the calyx tube, expanding rather abruptly to a funnelform throat, this yellow, with small purple spots and densely clothed within, on the

yellow anterior areas at the mouth, with large, yellow, club-shaped hairs, lobes rose-colored, sometimes almost white, approximately equal, commonly 2.5 to 5 mm in length and a little more in breadth, each with a conspicuous maroon spot at the base, or the spot sometimes wanting on the lower lobe, or even on all the lobes; stamens 4, included, the filaments arising from the corolla tube at a distance of about one-third the whole length of the corolla from the base, glandular-hairy for a millimeter or two at the base, smooth above, the posterior pair about 4 mm long, the anterior pair 2 to 3 mm longer; anthers smooth, connivent in pairs, the four anther cells of each pair about 1 mm long and nearly as broad, forming a cross, and dehiscent by slits for their whole length; ovary about 2 to 2.5 mm long to the end of the acuminate tip, 2-celled, with many ovules; style included, a little longer than the longer pair of stamens, sparingly hairy, the hairs short and gland-tipped; stigma peltate-funnel-shaped, about 1.5 mm high and 2 mm or more wide, the margin fringed with glandular hairs; capsule cartilaginous, lanceolate, somewhat sickle-shaped, somewhat compressed, the convex margin toward the back (the longer-toothed side) of the calyx, up to 9 mm in length, acute, puberulent, with a groove on each side opposite the placentae, dehiscent by a narrow slit from apex to base on the convex margin and a third or less its length from the apex on the concave margin, the convex, originally posterior margin standing outward and below at maturity and the concave margin inward and above, because of the twist in the fruiting pedicel; seed light brown to blackish brown, narrowly elliptical in outline, terete, abruptly contracted at the apex into a distinct beak, the body 0.7 to 1 mm long, 0.3 to 0.4 mm thick, minutely reticulated at full maturity, the areolae rectangular.

Type specimen in the United States National Herbarium, no. 1,630,865, collected on the foot of Nevares Peak, Funeral Mountains, Death Valley, California, altitude about 2,500 feet, April 6, 1935, by M. French Gilman (no. 1251), with both flowers and fruit. Collected also at the same locality, which is near Cowcreek, April 23, 1932, in flower (*Coville & Gilman* 400), March 18, 1935, in flower (*Gilman*), and in October, 1935 (*Gilman*), with an abundance of fruit on the dead stems. It was first found by Mr. Gilman in Cottonwood Canyon, Panamint Mountains, April 21, 1932 (*Coville & Gilman* 360), in flower, altitude 900 feet. The species has been collected also in Titus Canyon, Grapevine Mountains (*Gilman* 1196, April 29, 1935, past flowering). In all these localities the plants grew in the shaded crevices of limestone rocks.

The conspicuous flowers, rose-colored to almost white, with a large maroon spot at the base of each corolla lobe, and a golden throat; the habitat of the plant, in the shaded crevices of rocks; and its small size, all combine to give the species charm. The plant sometimes begins to flower when it is less than an inch in height and has only basal leaves. The larger specimens, up to 6 inches in height, are much branched from the base. A curious characteristic of the species is the position of the fruit. When the flowers open, the flower-stalk is straight and the long tooth of the calyx stands uppermost in the flower. Later the flower-stalk bends abruptly downward and to one side, and then upward and outward, in a sigmoid curve, and at the same time it twists about 180 degrees, until the long tooth of the calyx is on the lower side, the result being that the capsules, which are somewhat sickle-shaped,

stand out from the stem like the rustic coat-hooks of a log-cabin camp. The narrow slit in the ripe cartilaginous capsule is then on the lower and outer side, a position that presumably facilitates the scattering of the seeds. The fruits of some of the later (upper) flowers assume this position only partially, as if drouth and death had come too soon. In such cases the capsule is often straight and the split imperfect.

For more than three hundred years it has been generally admitted that a rose by any other name would smell as sweet. Without question, too, a rose would smell as sweet without a name. But it is my belief that any plant of sufficient interest to attract public notice should have a popular name as well as a Latin name. Plants of the genus *Mimulus* are commonly called monkeyflower, because their two-lipped corollas suggest a monkey's face. The present species, however, belongs to a group in which the corollas are not definitely two-lipped. This group of species has sometimes been separated from *Mimulus* as a distinct genus, *Eunanus*. The name *Eunanus* means a dwarf. I suggest for these dwarf species of *Mimulus* the common name, midget, and for this new species from Death Valley the common name, rock midget. The accompanying illustration will, I hope, confirm the propriety of this suggestion. Not all the plants of the desert are protected from heat and drouth by special adaptations, such as the absence of leaves, and the internal storage of water. In the present case the habitat itself lends protection to an annual that is tiny, thin-leaved, and delicate. Like the conies of ancient Palestine, the plants of this new species "are but a feeble folk, yet make they their houses in the rocks."

BOTANY.—*Leaf venation as a means of distinguishing* Cicuta *from* Angelica.[1] MIRIAM L. BOMHARD, U. S. Forest Service. (Communicated by FREDERICK V. COVILLE.)

The close resemblance of poisonous waterhemlocks (*Cicuta* spp.) to certain harmless umbellifers, particularly wet-habitat species of *Angelica*, indicates the importance of ascertaining diagnostic characters by which the waterhemlocks may be distinguished. Numerous and sudden fatalities have been caused by *Cicuta*, not only among domestic livestock but among human beings, especially children. The extremely toxic character of the underground parts ranks this genus as one of the most virulently poisonous groups of flowering plants native to the North Temperate Zone. *Cicuta* is chiefly a North American

[1] Received January 27, 1936.

genus, being widely distributed in wet places practically throughout the continent. Only one species, *C. virosa,* occurs in Europe and Asia; it is considered such a menace in some parts of northern Germany that its extermination is ordered by law.[2]

Because of the general resemblance of their compound leaves and white-flowered umbels, waterhemlocks are most often confused with species of *Angelica* in the western United States and Canada where both genera are well represented and widely distributed, and where angelicas characteristically grow in moist or wet situations.[3] Waterhemlocks are also sometimes mistaken for species of *Osmorhiza,* or for the woollyhead-parsnip (*Sphenosciadium capitellatum*), and some other members of the parsley family, many of which are excellent forage plants.[4] The fruits, it is true, provide a dependable means of recognizing all the genera mentioned. The flower clusters of *Osmorhiza* and *Sphenosciadium* are also sufficiently distinctive to serve for unmistakable recognition, but those of *Cicuta* and *Angelica* can scarcely be distinguished with certainty by persons not technically trained in botany. When neither the fruits nor flowers are present and the foliage alone must be depended upon for identification, accurate determination in the case of *Cicuta* and *Angelica* is often impossible on the basis of the leaf characters now used, and, as will be discussed later, the internal structure of the root crown or rootstock has proved to be unreliable as a guide in recognizing waterhemlocks.

The writer recently had occasion[5] to make a critical comparison of herbarium specimens of *Cicuta occidentalis,* the most widely distributed waterhemlock in the West, and *Angelica lyallii,* one of the most common and valuable forage species of the angelicas, and was impressed by the striking contrast in the venation of their leaflets. As is usual in serrate leaves, the secondary veins proceed toward the middle of the marginal teeth in the leaflets of *A. lyallii,* but in *C. occidentalis* they apparently end in the notches between the teeth. Such a definite difference in the venation of this representative species of a poisonous genus suggested the possibility of its usefulness as a diagnostic generic character.

[2] THELLUNG, ALBERT. *Umbelliferae,* in HEGI, GUSTAV. *Illustrirte Flora von Mittel-Europa* **5**: 1166. 1926. Munich.

[3] This was strikingly illustrated on a California range a number of years ago where *Angelica breweri* was eradicated at considerable expense in the belief that it was a waterhemlock. The writer's attention has also been called to a recent toxicological investigation made on a species of *Angelica* under the misapprehension that it was a species of *Cicuta.*

[4] The fact that waterhemlocks are also confused with toxic umbelliferous genera, such as *Berula, Oxypolis,* and *Sium,* need not be considered here.

[5] In connection with the preparation of the *Range Plant Handbook,* a forthcoming publication of the United States Forest Service.

A review of the literature relating to *Cicuta* brings to light that Bigelow,[6] in the first volume of his *American Medical Botany*, published in 1817, was probably the first to note that, in the eastern spotted waterhemlock (*C. maculata*), "The veins end in the notches, and not at the points of the serratures"; his excellent colored plate clearly shows the leaf venation. Rafinesque's description of this species also mentions "with veins ending at the notches, which is very unusual."[7] Torrey and Gray[8] refer to this characteristic venation of *C. maculata*, but credit Darlington[9] (instead of Bigelow) with first having observed this feature. In the first five editions of Gray's *Manual of Botany*, the termination of the veins in the notches of the leaflets is given in the description of the genus *Cicuta* which included only *C. maculata* and *C. bulbifera.* In 1868, Gray published his new species, *C. californica;* in the original description, he states, "venis primariis tenuibus in dentes disinentibus,"[10] and definitely points out that this differs from the venation of *C. maculata.* Gray's observation that the veins run to the teeth in *C. californica* no doubt accounts for the omission of reference to leaflet venation in generic descriptions of *Cicuta* in subsequent editions of his *Manual*, even though this native California species is quite outside the geographic range of that work. However, the characteristic venation of the leaflets of the eastern spotted waterhemlock has long been recognized as specific and is referred to in several of our standard manuals which describe the plants of Canada and the southeastern or eastern United States and in various publications on poisonous or medical plants.

It is remarkable that none of the current plant manuals and floras of western North America mention this similar peculiarity of venation for any of the western waterhemlocks. Chesnut and Wilcox[11] published, in 1901, a very good figure of western waterhemlock (*C. occidentalis*) clearly showing the termination of the veins in the notches of the leaflets but not calling attention to this feature in the text. Certain other investigators of poisonous plants have used illustrations showing the venation of this species; Jacobson[12] mentions it when

[6] Bigelow, Jacob. *American Medical Botany* **1**: 127, pl. 12. 1817. Boston.

[7] Rafinesque, C. S. *Medical Flora; or, Manual of the medical botany of the United States of North America* **1**: 108, fig. 22. 1828. Philadelphia.

[8] Torrey, John, and Gray, Asa. *A Flora of North America* **1**: 610. 1840. New York.

[9] Darlington, in his *Flora Cestrica* (1837), does call attention to the termination of the veins in the notches of the leaflets of *C. maculata.*

[10] Gray, Asa. *Characters of new plants of California and elsewhere.* Proc. Am. Acad. Arts & Sciences **7**: 344–345. 1868.

[11] Chesnut, V. K., and Wilcox, E. V. *The stock-poisoning plants of Montana; a preliminary report.* U. S. Dept. Agr. Div. Bot. Bull. **26**: 80–86, pl. 7. 1901.

[12] Jacobson, C. Alfred. *Water Hemlock (Cicuta).* Univ. Nevada Agr. Exp. Sta. Tech. Bull. **81**: 15. 1915.

describing the "*Cicuta occidentalis-vagans* group." Greene's original descriptions of *C. ampla* and *C. arguta* refer to the trend of the veins but, unfortunately, the meaning is ambiguous.[13]

No statement as to the possible importance of leaflet venation as an aid in recognizing other species of waterhemlocks has come to the author's attention. In order to discover whether this character could be used in distinguishing *Cicuta* from *Angelica*, the writer has examined all the available herbarium specimens (over 1,800) of these two genera in the collections of the United States Forest Service, the New York Botanical Garden, and the United States National Herbarium. Even without the aid of a hand lens, the principal veins are, for the most part, clearly visible on the under side of the leaflets, especially in *Cicuta*. It was found that the secondary veins of the leaflets are definitely directed toward the notches in all the species of *Cicuta* except *C. californica*. In those species in which this character is most clear-cut and easily recognized, the veins apparently end in the notches of the leaflet margins. The actual termination of the veins may be seen upon closer examination; enlarged cuts showing the venation of several of the marginal teeth of the leaflets of five species of *Cicuta* (Fig. 1.—A, B, C, D, E) make clear that it is the *direction* or *trend* of the veins toward the notches which must be recognized as diagnostic, since the veins or their branches continue beyond the notches along the edges of the teeth, either coinciding with the margin or running more or less parallel to it, terminating in the frequently spinulose tips of the teeth. This is in direct contrast to the condition in *Angelica*, where the secondary veins proceed directly toward the middle of the teeth, notwithstanding the fact that subsidiary veins branch off to the notches and continue along the margin, as can be seen in the enlarged illustrations of the marginal teeth in two species of *Angelica* (Fig. 1.—F, G).

This distinctive venation of the waterhemlocks is obvious in *Cicuta maculata*, *C. curtisii*, *C. occidentalis*, *C. bolanderi*, *C. douglasii*, and in the European *C. virosa*. Particularly in the first four of these species, the veins are more or less elevated and widely spaced; their trend in the direction of the notches of the coarse, evenly spaced serrations may be determined at a glance. The fact that the leaflets of some specimens of *C. douglasii* tend toward an incised-serrate margin (Fig. 1.—E) must be taken into consideration when noting the veins in this species; in some of the deeper serrations, the veins proceed to

[13] GREENE, EDWARD L. *New species of Cicuta.* Leaflets **2**: 241, 238. 1910–1912. Washington, D. C.

the middle of the teeth (behaving much as midribs), although they are directed toward the notches in the majority of the serrations precisely as in other specimens in which the margin is not incised but evenly and coarsely serrate. In *C. vagans*, the veins proceed toward the notches but tend to become much less prominent near the margin, especially in the upper portion of the leaflets. *C. bulbifera* is a distinctive species bearing clustered bulblets in the axils of the upper reduced leaves; its slender leaflets, remotely serrate above and often

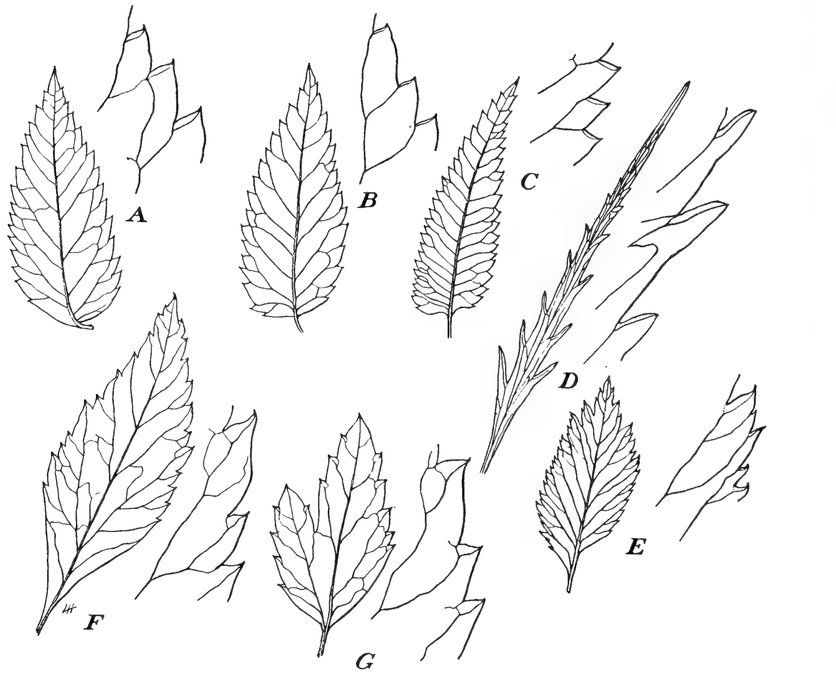


Fig. 1.—Leaflet venation in *Cicuta* (A–E) and *Angelica* (F, G). A, *C. occidentalis;* B, *C. curtisii;* C, *C. bolanderi;* D, *C. bulbifera;* E, *C. douglasii;* F, *A. lyallii;* G, *A. breweri.* Leaflet in A, B, C, E, F, and G, one-half nat. size; D, nat. size. Detail of marginal teeth to the right of each leaflet, one and one-half nat. size; D, twice nat. size. Drawn by Leta Hughey.

lobed below, may be so delicate that the direction of the veins cannot be clearly seen without the aid of a lens (Fig. 1.—D).

The only exception to the rule that in *Cicuta* the veins apparently end in the notches of the leaflets is *C. californica*, but this species is exceptional in other respects as well, and is certainly not a typical *Cicuta.* California waterhemlock is practically an aquatic and has a rather restricted range in coastal California. There is no possibility of confusing it with either of the two species of *Angelica* (*A. hendersonii* and *A. tomentosa*) which occur within its range because these

angelicas may be recognized by distinctive leaf differences other than venation.

In all the species of *Angelica* examined, the veins proceed toward the middle of the teeth. *A. lyallii* (Fig. 1.—F) may be considered typical of the species occurring in the United States and Canada. *A. breweri* is illustrated (Fig. 1.—G) to emphasize the fact that, even though a branch vein is sent off to the notch, the secondary vein continues directly to the tip of the tooth. In some exotic species of *Angelica* which possess delicate, much divided, or otherwise distinctive leaves, recognition of the characteristic form of the leaflets renders the traditional vein-to-tooth character relatively unimportant.

Since Thellung[14] reports that, in Europe, *Cicuta virosa* is sometimes confused with *Angelica silvestris*, which in the earlier stages of growth furnishes forage for cattle, particular attention was given to an examination of available herbarium specimens of these two species. It was found that the veins are easily traced toward the notches in the narrow, lanceolate to linear, sharply serrate leaflets of *C. virosa* and directly to the middle of the teeth in the ovate leaflets of *A. silvestris*. This difference in venation has apparently been overlooked by recent European investigators who mention only the narrowness of the leaflets and the usual chambered character of the root crown as aids in identifying the poisonous waterhemlocks. Attention is called, however, to the fact that the root crown is occasionally solid.[15]

Recognition of the presence of cross-partitions in the underground parts of waterhemlocks has been strongly advanced as an infallible guide in identifying these plants. This is, however, by no means a trustworthy criterion, because, although it is true that transverse partitions are characteristic of the root crown or rootstock of older plants of all the waterhemlocks, these partitions are sometimes obscure, and, in younger plants, are often absent. Moreover, many species of *Angelica* (*A. lyallii*, *A. ampla*, *A. breweri*, etc.) sometimes have well-marked cross-partitions in their roots. In fact, the development of chambers in the thickened underground parts has been observed in various members of the *Umbelliferae*.

The distinctive venation of the waterhemlocks should serve as a convenient field character for the recognition of these dangerous plants and should prove particularly useful in the identification of young plants early in the spring when there is most danger of livestock-poisoning.

[14] THELLUNG, ALBERT. Op. cit., p. 1338.
[15] THELLUNG, ALBERT. Op. cit., p. 1164.

PALEOBOTANY.—*A fig from the Eocene of Virginia.*[1] EDWARD W. BERRY, Johns Hopkins University.

The Eocene of Maryland and Virginia comprises a series of exclusively marine and often highly fossiliferous sediments segregated into an older Aquia and a younger Nanjemoy formation which were described in detail in 1901 by Clark and Martin.[2] Traces of the land vegetation of the time are represented by occasional drift fruits and fragments of wood.

The rather extensive investigations leading up to the report cited above resulted in the discovery of only a single plant—fruits determined by Hollick (Idem., p. 258, pl. 64, figs. 11, 12) as two varieties of a botanically unidentified species of *Carpolithus*. During the last 35

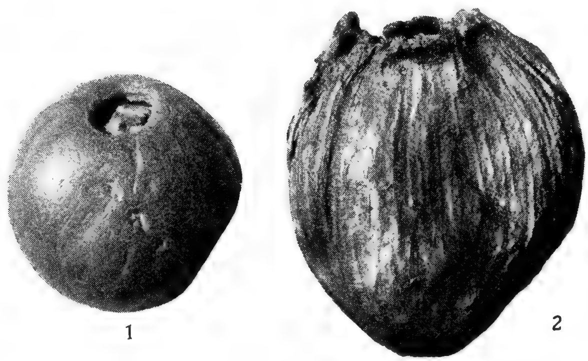


Fig. 1.—A probable fossil fig from Pense, Saskatchewan. Fig. 2.—*Ficus aquiana*, n. sp., from Belvedere Beach, Prince George County, Va.

years fairly continuous collecting has been prosecuted at the more prolific Eocene outcrops but it was not until the summer of 1933 that an identifiable land plant was discovered. This was a fairly complete cone of a pine[3] from near the type locality of the Aquia at Belvedere Beach, Prince George County, Va. Continued exploration of the excellent section at Belvedere Beach resulted in the discovery by R. L. Collins, during the summer of 1935, of a fruit of *Ficus*. This is much the most convincing fossil fig that I have ever seen, being more characteristic than the remarkable *Ficus ceratops* Knowlton[4] which is so abundant in the Lance formation of Montana, Wyoming, and western Canada. The new species may be named in allusion to the horizon which is not many miles from the type locality of the formation.

[1] Received November 11, 1935.
[2] CLARK, W. B., and MARTIN, G. C. *Eocene.* Md. Geol. Survey. 1901.
[3] BERRY, E. W. This JOURNAL **24**: 182, 1934.
[4] KNOWLTON, F. H. Torrey Bot. Club Bull. **38**: 389, figs. 1–4, 1911.

Ficus aquiana, n. sp. Fig. 2

In life this fig must have been approximately spherical. As a flattened fossil, there is a slight narrowing in the region known as the neck in the pyriform species, but the scar of attachment is invaginated with the body of the fig pushed forward on one flat side and backward on the other. The eye is open and relatively large, about 9 x 5 mm, with its edges somewhat thickened. The interior of the specimen was filled with sediment and no traces of seeds were observed, indicating that the plug or scales had rotted away while the fruit was floating and that the sediments which filled the interior entered through the eye, as the walls were perfectly intact when the specimen was collected. In modern figs of comparable size the eye is closed to a greater or less extent by scales of various forms. That this was the case in the fossil is indicated by the prominence of the vascular bundles on the thickened lip.

The ribs are numerous and well shown in the photograph. The walls of the fruit (properly the receptacle) are relatively thin and the cavity large and filled with sediment. This feature as well as the fact that this fruit floated from the land (probably stream borne) and became filled and covered by sediment and was lignified, is rather conclusive evidence that in life it was dry and woody instead of fleshy, as otherwise it would have rotted and failed of preservation. Its dimensions are, as preserved, about 4 cm in length, about 3.7 cm in diameter, and about 1.5 cm in thickness.

I have, unfortunately, no complete collection of the fruits of existing species of Ficus. One unidentified woody specimen is identical in surface ornamentation, but has a smaller eye and a shape like *Ficus ceratops.* The most similar recent fig seen is a specimen of *Ficus repens* Rotel collected by F. N. Meyer near Soochow, China; but I do not know if this specimen is typical of the species. It is about the same size as the fossil with similar thin woody walls. The ribbing is slightly less prominent on the outer surface. The actual eye is smaller but the apex is invaginated around the latter for about the area of what I have called the eye in the fossil and has the appearance of offering the possibility of macerating out to match the fossil. The general form is similar, i.e., roughly globular and inflated, but is produced into a short and slender neck. If the latter were softened by maceration and pushed during a compression similar to that undergone by the fossil, the result would not be very different. There is a possibility, although I regard it as remote, that my interpretation is wrong, and that what I regard as the base and the scar of attachment is the plugged eye, and what I regard as the eye is the broken neck. The lack of any reasonable explanation for such a break where the vascular strands would be concentrated, or for the opening to be symmetrical and lipped, seems to invalidate such an interpretation.

Occasional fruits of Ficus have been encountered and described from strata ranging in age from Upper Cretaceous to late Pleistocene. Except for casts in Pleistocene tuffs or travertine in France and Italy, these are mostly lignified, structureless and unsatisfactory objects for study. Exceptions to this statement are the present specimen and the late Upper Cretaceous or early Eocene form from the West referred to above and described by Knowlton in 1911.

In this connection I am figuring an object sent me by B. F. Baxter of Pense, Saskatchewan, from approximately the same horizon as *Ficus ceratops* Knowlton. This is a chalcedony pebble with faint indications of ribs and a pronounced umbilicus which might very well represent a fig "eye," since the eye-like plug is surrounded by a narrow cavity into which a fine needle can be inserted a distance of 4 mm inside the rim or lip. In color and form it bears a striking resemblance to a modern fig, but it would be unsafe to press such an identification without sacrificing the single specimen, and even this might not yield results. It seems to me that this probably represents a fig which has been replaced by chalcedony since it is hard to conceive of a pebble with an umbilicus and radial markings. On the other hand if it is of organic origin one would expect more than a single specimen. If additional specimens are found I would not hesitate to consider its identity as proved.

I have records, doubtless not complete, of 402 named species of fossil figs. The majority of these are based upon leaf impressions ranging in age from mid-Cretaceous to Recent. Doubtless a considerable number of these may be wrongly identified, but the majority can scarcely be disputed especially since they are occasionally associated with fruits. It would be an interesting speculation as to whether the setting of seeds in an Eocene fig required the intervention of ancestral *Blastophaga* wasps as is the case with some of the best cultivated figs. All of the several hundred existing species of figs do not however require caprification, but certainly the form of the fruit-multiple flowered on the inside of a hollow receptacle is to be correlated with insect pollination of some kind and if this be granted the habit was already established at the dawn of the Tertiary.

Much has been written of the place of origin of fig culture, Solms-Laubach suggesting southern Arabia, which seems doubtful to me. None who have written on this fascinating subject have had any knowledge of the fossil record or of the presence of *Ficus carica* (the edible fig) in Interglacial deposits (2nd and 3rd Interglacial) in both France and Italy, both fruits and leaves being found and both in this case highly characteristic. Fruits supposed to represent this species have even been described by Engelhardt and Kinkelin from the Pliocene of south Germany, but their identification is not so certain. A great many recent species other than *Ficus carica* are eaten occasionally or regularly in different parts of the world. Sturtevant (1919) names 18 species which are eaten regularly or in times of scarcity of food, and doubtless many more are occasionally eaten. I would not be

surprised if it were eventually shown that wild figs were present throughout the Mediterranean basin and were an article of diet of Paleolithic man, which is quite apart from the question as to where dried figs first became an article of commerce, which may well have been in eastern Mediterranean countries. The genus *Ficus*, as aforesaid, is a large one in modern floras with between five and six hundred species adapted to a variety of habitats, but confined to the warmer parts of the world, although by no means confined to the tropical zone.

The Eocene has yielded a prolific flora in the Mississippi embayment region and in western North America but practically nothing in eastern North America except the isolated lignite basin at Brandon, Vermont,[5] from which a large number of fruits and seeds have been described. The latter, as well as the present species of *Ficus*, indicate climatic conditions more genial than those indicated by the plants known from the Chesapeake Miocene, and probably somewhat more genial than the corresponding latitudes of the present day, but certainly to be denominated temperate, rather than tropical or even subtropical.

ZOOLOGY.—*New pocket gophers of the genus* Thomomys.[1] E. A. Goldman, Bureau of Biological Survey.

Twenty years have passed since the pocket gophers of the genus *Thomomys* were revised by Bailey (North Amer. Fauna, No. **39**: p. 1–136, Nov. 15, 1915). Much additional material has become available for study, and the tendency toward the recognition by name of less and less strongly marked stages of differentiation has resulted in the description of many new forms, especially in the plastic *Thomomys bottae* group.

These extremely sedentary animals inhabit regions of highly diversified topography and climate. Populations consist of colonies which appear to be loosely and more or less intermittently in contact with neighboring colonies, or continuity of range may have become partially or completely interrupted by barriers associated with geological history. In such a setting full play has been given to forces that bring about localized modification, in response to environmental and genetic factors. The result has been the production of a profusion of forms, varying greatly in degree of minor differentiation, and yet maintaining the same pattern of more essential characters with remarkable

[5] Berry, E. W. Am Jour. Sci. **47**: 211–216. 1919.

[1] Received December 16, 1935.

fidelity. How many should be segregated, and whether particular ones are best designated by binomial or trinomial names are problems depending for ultimate solution on coördinated studies in the field and laboratory.

The criterion—presence or absence (observed or assumed) of individuals possessing intermediate characteristics—for distinguishing between species and subspecies is excellent in theory but not always satisfactorily applicable in practice. Uncertainty must exist where the number of specimens is insufficient to determine the range of individual variation, and where detailed knowledge of field conditions is lacking. A complicating factor is evidence that some forms may intergrade in one region and occur in close juxtaposition without apparent intergradation in another. Until the coördinated field and laboratory studies can be completed the choice of binomial or trinomial names must depend on individual judgment of the evidence in each case.

In the treatment of forms I have endeavored to be as consistent as possible. Experience in classifying pocket gophers, and many other mammals, has shown that trinomials may usually be applied with safety to populations exhibiting differential characters in combinations known to be of subspecific value only, elsewhere in the group.

Thomomys muralis, sp. nov.

Grand Canyon Pocket Gopher

Type.—From lower end of Prospect Valley, Grand Canyon, Hualpai Indian Reservation, Arizona (altitude 4,500 feet), No. 202580, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by E. A. Goldman, October 3, 1913. Original number 22264.

Distribution.—Isolated on terraces along the inner gorge, far below the outer rim in Prospect Valley, a lateral pocket within the Grand Canyon, near the eastern end of the Hualpai Indian Reservation, Arizona.

General characters.—A diminutive, ochraceous buffy species, separated from the ranges of the similarly-colored forms of the region by an interposed arm of the range of the darker subspecies, *Thomomys bottae fulvus.* Differing from *fulvus* in much smaller size, lighter color, and cranial proportions. Very similar in size and color, and bearing a close general resemblance to *Thomomys bottae desertorum,* but geographically isolated, and cranial details indicating no intergradation.

Color.—*Type* (acquiring fresh pelage): Upper parts between light ochraceous buff and ochraceous buff (Ridgway, 1912), purest along sides, thinly mixed with black on top of head and median dorsal area; outer sides of forearms light buff; thighs nearly pure white; under parts overlaid with white; muzzle blackish; ears entirely black along with the black postauricular patches usual in the group; feet and tail white. One of the topotypes is near tawny in general color of upper parts, with under parts overlaid with light ochraceous buff.

Skull.—Very similar in general to that of *T. b. desertorum,* but braincase more rounded and inflated, the basicranial region tending to bulge more prominently posteriorly; frontal region broader; premaxillae usually less extended posteriorly, the ends more nearly conterminous with nasals; upper incisors more strongly recurved (slightly more procumbent in *desertorum*). Compared with that of *T. b. fulvus* the skull is much smaller and more delicate in structure, and differs in detail in about the same characters as form *desertorum.*

Measurements.—*Type*: Total length, 194 mm; tail, 64; hind foot, 26. Two adult female topotypes: 182–190; 57–56; 24.5–25.5, respectively. *Skull* (type): Occipitonasal length, 33.2; zygomatic breadth, 20.5; breadth across squamosals (over mastoids), 17.7; interorbital constriction, 7; length of nasals, 11.3; maxillary toothrow (alveoli), 7.2.

Remarks.—The geographic isolation of *Thomomys muralis* in the Grand Canyon appears to be complete. In places it was found inhabiting strips of soil on ledges only a few feet wide, bounded above and below by vertical cliffs hundreds of feet high.

Specimens examined.—Four, all from the type locality.

Thomomys bottae desitus, subsp. nov.

Big Sandy River Pocket Gopher

Type.—From Big Sandy River, near Owen, Mohave County, Arizona (altitude 2,000 feet). No 227802, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by E. A. Goldman, September 21, 1917. Original number 23332.

Distribution.—Big Sandy River Valley and desert region southeastward to Wickenburg; probably also including the valley of the Bill Williams River, Arizona.

General characters.—Very similar in color and form of cranium to *Thomomys bottae desertorum* of Detrital Valley, but decidedly larger. Differing from *Thomomys bottae chrysonotus* of the Colorado River Indian Reservation, and *Thomomys bottae cervinus* of the Salt River Valley, in smaller size and more tawny coloration. About equal in size to *Thomomys bottae fulvus* of the Mogollon Plateau region, but color much clearer tawny, the back less mixed with black, and cranial details distinctive.

Color.—*Type* (acquiring fresh pelage): Upper parts in general between tawny and ochraceous tawny (Ridgway, 1912), only slightly darkened on top of head and middle of back by black-tipped hairs; outer sides of forearms light ochraceous buff; lower part of sides and thighs whitish; under parts overlaid with white, tinged with buff across throat and chest; muzzle blackish; ears black, except anterior margin which is buffy, the confluent black postauricular markings prominent; feet white; tail buffy above, whitish below, becoming white all around near tip.

Skull.—Essentially like that of *T. b desertorum,* but much larger. Compared with those of *T. b. chrysonotus* and *T. b. cervinus* the skull is much smaller, and less angular, the supraoccipital region more fully inflated (lacking the deep, median supraoccipital excavation usually present in *chrysonotus* and *cervinus*); audital bullae much smaller. Very similar to that of *T. b. fulvus,* but bullae larger.

Measurements.—Type: Total length, 230 mm; tail, 70; hind foot, 30.5. Two adult male topotypes: 219–238; 72–75; 30–31, respectively. An adult female topotype: 210; 62; 29.5. *Skull* (type): Occipitonasal length, 39.5; zygomatic breadth, 24.8; breadth across squamosals (over mastoids), 20; interorbital constriction, 6.8; length of nasals, 14.7; maxillary toothrow (alveoli), 8.2.

Remarks.—At the type locality *T. b. desitus* inhabits the loose sand along the broad alluvial river bottom, habitat in marked contrast with the harder upland soils perforated by its geographic neighbor, *T. b. desertorum.* The skull of *desitus* indicates close relationship to *fulvus,* and it is obviously a desert representative of the same group.

Specimens examined.—Total number, 22, all from Arizona as follows: Big Sandy River (near Owen), 5; Big Sandy River (Neale's Ranch, at 2,000 feet altitude), 7; Wickenburg, 10.

Thomomys bottae hualpaiensis, subsp. nov.

Hualpai Mountain Pocket Gopher

Type.—From Hualpai Peak, Hualpai Mountains, Mohave County, Arizona (altitude 7,000 feet). No. 227796, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by E. A. Goldman, October 6, 1917. Original number 23351.

Distribution.—Known only from the Hualpai Mountains, Arizona.

General characters.—A light ochraceous buffy subspecies of medium size. Closely allied to *Thomomys bottae desitus,* of the adjoining valley of the Big Sandy River; size about the same, but color distinctly paler; skull differing in detail. Similar in general to *Thomomys bottae desertorum* of the desert plains of the Detrital Valley to the north, but considerably larger and paler colored; cranial characters also distinctive.

Color.—Type: Upper parts near light ochraceous buff (Ridgway, 1912), clearest along sides, thinly mixed with black on top of head and over back; forearms and thighs pale ochraceous buff; under parts in general overlaid with pale ochraceous buff, varying to a deeper tint on throat and chest; a pure white spot on chin; muzzle blackish; anterior borders of ears invaded by buffy tone of head; rest of ears and postauricular spots deep black; feet white; tail brownish above on basal two-thirds, whitish below, and white all around on terminal third.

Skull.—Closely resembling that of *T. b. desitus,* but braincase somewhat lower; zygomata usually more slender; nasals more wedge-shaped, narrower posteriorly; audital bullae slightly smaller, dentition about the same. Compared with that of *T. b. desertorum* the skull differs mainly in decidedly larger size.

Measurements.—Type: Total length, 245 mm; tail, 78; hind foot, 31.5. *Skull* (type): Occipitonasal length, 40; zygomatic breadth, 25; breadth across squamosals (over mastoids), 20; interorbital constriction, 6.7; length of nasals, 14.8; maxillary toothrow (alveoli), 7.8.

Remarks.—This high mountain form most closely resembles its near geographic neighbor, *desitus,* but is distinguished by paler color. It requires

no close comparison with *chrysonotus* which is much larger and still paler, or with *fulvus* which is much darker.

Specimens examined.—Seven, all from the type locality.

Thomomys bottae internatus, subsp. nov.

Upper Arkansas River Valley Pocket Gopher

Type.—From Salida, Chaffee County, Colorado (altitude 7,000 feet). No. 150997, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Merritt Cary, November 10, 1907. Original number 1247.

Distribution.—High valleys along the eastern side of the Rocky Mountains from the Upper Arkansas River Valley, Colorado, south to northeastern New Mexico.

General characters.—A large, ochraceous buffy or tawny subspecies. Closely resembling *Thomomys bottae pervagus* of the Upper Rio Grande Valley, New Mexico, but smaller; color very similar; cranial details distinctive. Similar in general to *Thomomys bottae ruidosae* of south-central New Mexico, but smaller; color much lighter, more uniform, not strongly mixed with black as in *ruidosae;* skull also different.

Color.—*Type:* Upper and under parts between ochraceous buff and tawny (Ridgway, 1912), the top of head and back faintly darkened by black-tipped hairs; muzzle blackish, except lips which are whitish; ears encircled by black; feet white; tail brownish above, white below, becoming whitish all around at tip. In some specimens the under parts vary to light ochraceous buff.

Skull.—Very similar to that of *T. b. pervagus,* but smaller and lighter in structure; premaxillae usually less extended posteriorly beyond ends of nasals; audital bullae smaller; dentition lighter. Compared with that of *T. b. ruidosae* the skull is larger and more angular, the temporal ridges more prominent; zygomata less strongly bowed outward posteriorly (widest anteriorly); maxillary arm of zygoma relatively heavier; dentition similar.

Measurements.—*Type:* Total length, 233 mm; tail, 74; hind foot, 32. Five adult female topotypes: 231 (220–239); 76 (73–80); 32 (31–34). *Skull* (type): Occipitonasal length, 39.1; zygomatic breadth, 24.2; breadth across squamosals (over mastoids), 19.7; interorbital constriction, 6.7; length of nasals, 13.9; maxillary toothrow (alveoli), 8.1.

Remarks.—The range of *T. b. internatus* seems to represent an extension of the *T. bottae* group northward along the east side of the Rocky Mountains. In general characters the present form closely approaches *T. b. pervagus* from which, however, it appears to be completely isolated by the high mountains inhabited by *T. fossor* to the westward. Specimens from northeastern New Mexico grade toward *T. b. ruidosae.*

Specimens examined.—Total number, 19, as follows:

COLORADO: Gardner, 2; Salida, 8.

NEW MEXICO: Folsom, 2; Oak Canyon (near Folsom), 2; Sierra Grande, 4; Trinchera Pass (mouth), Colfax County, 1.

Thomomys bottae howelli, subsp. nov.

Grand Junction Pocket Gopher

Type.—From Grand Junction, Mesa County, Colorado (altitude 4,600 feet). No 75684, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by A. H. Howell, November 7, 1895. Original number 493.

Distribution.—Known only from the type locality in the Grand River Valley, western Colorado.

General characters.—A rather large, pallid subspecies with a broad, flattened cranium. Similar to the palest specimens of *Thomomys bottae aureus* of the San Juan River Valley, southeastern Utah, in color, but under parts more thinly overlaid with buffy white, and cranial characters, especially the broad, flat braincase, distinctive. Approaching *Thomomys bottae osgoodi* of the Fremont River Valley, Utah, in color, but much larger and skull widely different.

Color.—*Type* (winter pelage): Upper parts in general between tilleul buff and pale olive buff (Ridgway, 1912), somewhat darkened on head by a mixture of cinnamon buff and brown; a few inconspicuous dusky-tipped hairs along median line of back; muzzle dusky; ears and postauricular spots deep, contrasting black; under parts thinly overlaid with buffy white, the hairs becoming pure white to roots on inguinal region; thighs pure white to roots all around; feet white; tail buffy whitish, slightly paler below than above.

Skull.—Similar in general to that of *T. b. aureus*, but braincase conspicuously broader and flatter; zygomata more widely spreading; nasals shorter; premaxillae more attenuate posteriorly; interparietal larger; audital bullae more rounded and fully inflated anteriorly; incisors short, as in *aureus*, but less strongly recurved. Compared with that of *T. b. osgoodi* the skull is much larger, with flatter braincase, shorter nasals, and posteriorly narrower premaxillae.

Measurements.—*Type:* Total length, 219 mm; tail, 71; hind foot, 29. *Skull* (type): Occipitonasal length, 36.8; zygomatic breadth, 23.7; breadth across squamosals (over mastoids), 20; height of braincase (over audital bullae), 12.1; interorbital constriction, 7.1; length of nasals, 10.8; maxillary toothrow (alveoli), 7.4.

Remarks.—*T. b. howelli* is based on a single specimen exhibiting characters which, in view of geographic isolation, seem to warrant subspecific recognition. It is more closely allied to *T. b. aureus* than to any other known form.

Thomomys bottae optabilis, subsp. nov.

Naturita Creek Valley Pocket Gopher

Type.—From Coventry, Naturita Creek Valley, Montrose County, Colorado (altitude 6,500 feet). No. 149962, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Merritt Cary, July 31, 1907. Original number 1105.

Distribution.—Cultivated flats between Naturita Creek and the San Miguel River, southern Montrose County, Colorado; limits of range unknown.

General characters.—A large, cinnamon-buff subspecies. Size about as in the allied form, *Thomomys bottae aureus* of the San Juan River Valley, southeastern Utah, but color decidedly darker and cranial details, especially the more widely spreading zygomata, distinctive. Also similar in size to the

higher mountain form, *Thomomys bottae apache*, of the Jicarilla Indian Reservation, northwestern New Mexico, but color richer, more buffy, less dusky, and skull combining differential features.

Color.—Type (acquiring summer pelage): Upper parts near cinnamon buff (Ridgway, 1912), purest along sides, finely and evenly mixed with black on top of head and over back; under parts in general overlaid with pinkish buff; hairs on chin and middle of throat pure white to roots; forearms and thighs like under parts; muzzle and middle of face blackish; ears and postauricular areas black; feet white; tail buffy grayish above, somewhat lighter below to near tip which is silvery white all around.

Skull.—Large, but rather light in structure. Similar to that of *T. b. aureus*, but less robust; frontonasal region more depressed along median line; zygomata more slender, but more widely and squarely spreading, the antero-external angle weakly developed; nasals broader posteriorly, less wedge-shaped, the sides more nearly parallel; premaxillae narrower posteriorly; anterior nares higher, the nasals less flattened above; exposed portion of upper incisors longer, more procumbent. Very similar in general to that of *T. b. apache*, but lighter in structure; rostrum more slender; premaxillae narrower; frontal region narrower, more constricted; exposed portion of incisors longer.

Measurements.—Type: Total length, 250 mm; tail, 76; hind foot, 32. *Skull* (type): Occipitonasal length, 42.9; zygomatic breadth (at antero-external angle), 27.2; breadth across squamosals (over mastoids), 21.4; interorbital constriction, 6.4; length of nasals, 14.2; maxillary toothrow (alveoli), 8.2.

Remarks.—T. b. optabilis inhabits high valley areas, above the range of *T. b. aureus*, along the western side of the Rocky Mountains. In cranial characters it approaches *T. b. apache*, but is readily separated by richer coloration. It requires no close comparison with the pallid subspecies, *T. b. howelli*, of the Grand River Valley.

Specimens examined.—Two, from the type locality.

Thomomys bottae guadalupensis, subsp. nov.

Guadalupe Mountains Pocket Gopher

Type.—From McKittrick Canyon, Guadalupe Mountains, Texas (altitude 7,800 feet). No. 109225, ♂ adult, skin and skull, U.S. National Museum (Biological Survey collection); collected by Vernon Bailey, August 22, 1901. Original number 7821.

Distribution.—Guadalupe Mountains of southern New Mexico and western Texas.

General characters.—A light colored, medium-sized subspecies; pectoral mammae two pairs as usual in forms of *bottae;* very similar in general to *Thomomys bottae texensis* of the Davis Mountains, but color usually lighter; skull more massive, and differing in detail. Contrasting strongly in lighter color, compared with *Thomomys bottae ruidosae* of south central New Mexico, and cranial characters also distinctive.

Color.—Type (summer pelage): Upper parts light ochraceous buff (Ridgway, 1912), slightly darkened on top of head and over back by black-tipped hairs; under parts near pale ochraceous salmon, this tone extending upward over lower part of sides and including forearms and thighs; ears black,

invaded by buff anteriorly; black patches behind ears small; muzzle brownish; feet white; tail with a brownish tinge above, white below. Color varying in topotypes to between ochraceous buff and tawny above, and light ochraceous buff below.

Skull.—Similar to that of *T. b. texensis*, but broader and heavier; frontal region broader; nasals broader; premaxillae usually less extended beyond ends of nasals posteriorly; incisors shorter, decurvature about the same. Size of cranium about as in *T. b. ruidosae*, but rostrum and nasals shorter; frontal region broader; zygomata less strongly bowed outward posteriorly; incisors shorter, decurvature about the same.

Measurements.—*Type:* Total length, 218 mm; tail, 64; hind foot, 29. An adult female topotype: 200; 65; 29. *Skull* (type): Occipitonasal length, 37.1; zygomatic breadth, 23.7; breadth across squamosals (over mastoids), 19.0; interorbital constriction, 6.9; length of nasals, 12.3; maxillary toothrow (alveoli), 6.9.

Remarks.—*T. b. guadalupensis* is distinguished by pale coloration combined with cranial features unlike those of any of its geographic neighbors. The upper incisors are remarkably short in the older adults, especially males.

Specimens examined.—Total number, 6, as follows:

NEW MEXICO: Guadalupe Mountains (Dog Canyon, 6,800 feet), 2.

TEXAS: Guadalupe Mountains (McKittrick Canyon), 4.

Thomomys lachuguilla limitaris, subsp. nov.

Big Bend Pocket Gopher

Type.—From four miles west of Boquillas, Brewster County, Texas. No. 110339, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Vernon Bailey, May 28, 1901. Original number 7659.

Distribution.—Northern side of the Rio Grande River Valley, from the "Big Bend" east at least to Devils River, and north to Castle Mountains, Texas.

General characters.—A small, pale buffy subspecies. Closely allied to *Thomomys lachuguilla lachuguilla* of the El Paso region, but still smaller, throat and chest white instead of buffy, and skull differing in detail; mammae, pectoral two pairs, inguinal two pairs, total eight as in *lachuguilla*. Similar in size and color to *Thomomys umbrinus perditus*, a geographic neighbor south of the Rio Grande, but pectoral mammae two pairs instead of one pair, and cranial characters different.

Color.—*Type* (unworn summer pelage): Upper parts near pinkish buff (Ridgway, 1912), the top of head and back somewhat darkened by black-tipped hairs; under parts overlaid with white; forearms, thighs, and feet white; muzzle brownish; ears black, except anterior margins which are buffy; black postauricular patches rather small; tail thinly clothed with whitish hairs above and below.

Skull.—Similar to that of *T. l. lachuguilla* in form, but still smaller, more delicate in structure; zygomata relatively more slender; premaxillae less extended beyond ends of nasals posteriorly; audital bullae relatively small-

er; dentition lighter; upper incisors decurved about as in *lachuguilla.* Compared with that of *T. u. perditus* the skull is similar in size and delicate structure, but the zygomata are less strongly bowed outward, the sides more nearly parallel; nasals less wedge-shaped, the posterior ends truncate instead of emarginate; lachrymals articulating less broadly with maxillae, as viewed from above; upper incisors more decurved, less procumbent

Measurements.—*Type:* Total length, 200 mm; tail, 67; hind foot, 27. An adult female topotype: 208; 66; 28. *Skull* (type): Occipitonasal length, 32.5; zygomatic breadth, 20.2; breadth across squamosals (over mastoids), 17; interorbital constriction, 7; length of nasals, 10.8; maxillary toothrow (alveoli), 6.8.

Remarks.—This new form is based upon a few specimens from several localities that exhibit too great a departure in cranial details for satisfactory reference to typical *lachuguilla.* It bears a superficial resemblance to *Thomomys umbrinus perditus,* but a summation of characters indicate specific distinction.

Specimens examined.—Total number, 9, all from Texas, as follows: Boquillas (type locality), 2; Castle Mountains, 1; Comstock, 3; Devils River, 13 miles below Juno, 1; Marathon, 1; Samuels, 19 miles west of Langtry, 1.

Thomomys lachuguilla confinalis, subsp. nov.

Rock Springs Pocket Gopher

Type.—From 35 miles east of Rock Springs, Texas (altitude 2,450 feet). No. 117571, ♂ subadult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Vernon Bailey, July 11, 1902. Original number 7910.

Distribution.—Known only from the type locality in the upper part of the Nueces River Valley, central southern Texas.

General characters.—A small, cinnamon form, with weakly developed skull. Similar in general to *Thomomys lachuguilla limitaris,* but color richer, near cinnamon instead of pinkish buff, and skull more delicate in structure.

Color.—*Type* (acquiring fresh pelage): Head and anterior part of back near cinnamon (Ridgway, 1912), moderately mixed with black; rest of upper parts in worn pelage dull grayish; under parts white, the hairs white to roots on throat, under sides of forearms and inguinal region; forearms tinged with buff along outer sides; muzzle blackish; ears black, becoming buffy near anterior base; forefeet, thighs, and hind feet white; tail light brownish above, white below.

Skull.—Similar in size to that of *T. l. limitaris,* but more slender; zygomata narrower and tending to converge anteriorly, the sides less nearly parallel; premaxillae more prolonged beyond ends of nasals posteriorly; interparietal quadrate and nasals nearly truncate posteriorly as in *limitaris;* palate narrower; dentition lighter; incisors thinner and narrower; maxillary toothrow shorter.

Measurements.—*Type:* Total length, 200 mm; tail, 60; hind foot, 28. *Skull* (type): Occipitonasal length, 32.8, zygomatic breadth, 19.4; breadth across squamosals (over mastoids), 16.5; interorbital constrictions, 6.2; length of nasals, 10.8; maxillary toothrow (alveoli), 5.9.

Remarks.—*T. l. confinalis* is based upon a single specimen representing the extreme eastern limit of the known range of the genus in Texas. The combination of color and cranial details appear to be well beyond the range of individual variation in *T. l. limitaris,* the only form with which it requires close comparison.

Thomomys pectoralis, sp. nov.

Carlsbad Pocket Gopher

Type.—From vicinity of Carlsbad Cave, Carlsbad Cave National Monument, Eddy County, New Mexico. No. 244372, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Vernon Bailey, March 17, 1924. Original number 10222.

Distribution.—Known only from the type locality in the Pecos River Valley, southeastern New Mexico.

General characters.—A small, pinkish buffy species, closely resembling *Thomomys lachuguilla* of the Rio Grande Valley region near El Paso, Texas, but smaller; pectoral mammae apparently limited to a single pair, instead of two pairs as in *lachuguilla;* skull smaller, less massive, and differing in detail. Size much smaller and color paler than in *Thomomys bottae guadalupensis* of the neighboring Guadalupe Mountains; pectoral mammae apparently one pair, instead of two pairs as in *guadalupensis;* cranial characters quite different.

Color.—*Type:* Upper parts near pinkish buff (Ridgway, 1912), slightly darkened on head and over dorsum by admixture of black-tipped hairs; under parts overlaid with pinkish buff, extending upward to include outer sides of forearms and thighs; muzzle blackish; ears encircled by black; feet white; tail brownish above, white below.

Skull.—Similar in general to that of *T. lachuguilla,* but smaller, less massive; rostrum narrower; zygomata more slender; interparietal more triangular; premaxillae less extended beyond ends of nasals posteriorly; bullae smaller; upper incisors thinner and slightly more procumbent. Compared with that of *T. b. guadelupensis* the skull is smaller, less angular, and lighter in structure; interparietal more triangular; bullae more smoothly rounded; dentition similar.

Measurements.—*Type:* Total length, 186 mm; tail, 48; hind foot, 25. An adult female topotype: 188; 55; 26. *Skull* (type): Occipitonasal length, 34; zygomatic breadth, 21.8; breadth across squamosals (over mastoids), 18; interorbital constriction, 6.7; length of nasals, 11.3; maxillary toothrow (alveoli), 6.8.

Remarks.—This little pocket gopher presents a departure from the neighboring forms in the apparent reduction of the pectoral mammae to a single pair. At least I have been able to find only one pair in a topotype in which the mammae had been functional and are clearly visible. In this character the present form agrees with *Thomomys umbrinus* of Mexico, but differs in important cranial features and requires no close comparison.

Specimens examined.—Three, all from the type locality.

ZOOLOGY.—*Chinese spiders of the families Agelenidae, Pisauridae, and Sparassidae.*[1] IRVING FOX (Communicated by C. F. W. MUESEBECK.)

In the course of identification of Chinese spiders which have accumulated in the United States National Museum, several new species were found. These new species, together with others noted below, were collected by Dr. D. C. Graham chiefly in Szechwan Province, China, during the years 1923, to 1930.

I wish to thank the authorities of the United States National Museum, especially Dr. E. A. Chapin, for placing these collections in my hands, and for their helpfulness and courtesy while this work was in progress.

Family AGELENIDAE

Agelena difficilis, n. sp. Fig. 5

Male.—Total length, 9.40 mm. Carapace, 4.85 mm long, 3.56 mm wide. Abdomen, 4.95 mm long, 3.07 mm wide.

Carapace brown with a lighter median band which widens from the eye rows backward for about a fourth of the length of the carapace; it then abruptly narrows to a point and ends at the longitudinal furrow. Sides of the carapace with wide submarginal white stripes, and much narrower dark brown marginal ones. Clypeus reddish brown, chelicerae lighter, clothed with long white hairs. Sternum, labium, and endites reddish, darker than the coxae. Legs uniform light yellow, clothed with white hairs. Dorsum and sides of the abdomen dark brown, venter with a broad brown stripe extending from the epigastric furrow to the spinnerets. Spinnerets light brown, the last pair about twice as long as the first pair. The distal joint of the last pair of spinnerets about twice the length of the basal.

Eyes characteristically in two strongly procurved rows. Anterior median eyes closer to the laterals than to each other and slightly larger than the laterals. Eyes of the second row equal in size, equidistant, spaced about a diameter apart. The lateral eyes of both rows subequal and subcontiguous. Median ocular quadrangle about as long as wide, slightly wider in front than behind (15/14), the posterior median eyes about five-sixths the size of the anterior median. Clypeus equal in height to one and one-third times the diameter of an anterior median eye. Chelicerae with five teeth on the lower margin and three on the upper.

Tibia I armed below with a submedian and a basal pair of spines; tibiae II, III, IV, with a single submedian and a single basal spine. Tibia and patella I, 5.94 mm long. Tibia and patella IV, 5.84 mm long. Patella of the palpus about five-sevenths the length of the tibia, both together about one-half the length of the femur. Distal edge of the patella with two sharp black spurs. Tibia hook-like inwardly.

Type locality.—China: Male holotype and 2 male paratypes from Suifu, Szechwan Province, October, 1930. U.S.N.M. Cat. No. 1149.

This spider resembles *Agelena japonica* Karsch in the possession of an embolus which is robust and projects forward. The embolus differs from

[1] Received November 11, 1935.

that of the latter species, however, in being spiral-shaped basally and forming a distinct coil distally, as is shown in Figure 5.

Agelena injuria, n. sp. Fig. 3

Male.—Total length, 11.78 mm. Carapace, 5.74 mm long, 4.85 mm wide. Abdomen, 6.14 mm long, 3.17 mm wide.

The carapace of this specimen is damaged, and therefore somewhat distorted. It is reddish brown with a faint lighter median band that is as wide as the eye rows anteriorly, but converges posteriorly to a narrower portion which disappears in the pronounced longitudinal groove. Sides of the carapace with wide submarginal bands of whitish hairs. Clypeus dark, chelicerae lighter, sparsely provided with white hairs. Sternum, labium, and endites dark red; labium and endites with much lighter edges. Legs light reddish or orange, patella, and the proximal ends of the femur and tibia darker. Dorsum of the abdomen dark brown, tinged with red at the base. Sides of the abdomen brown, the venter much paler, furnished with whitish stripes, one on each side, which more or less outline it. Spinnerets light brown in color, with the last pair about twice the length of the first pair. Distal joint of the last pair of spinnerets much longer than the basal (14/6).

Eyes characteristically in two strongly procurved rows. Eyes of the first row about the same size, the medians closer to the laterals than to each other. Eyes of the second row with the medians smaller than the laterals, equidistant, about one diameter of a posterior lateral eye apart. The lateral eyes of both rows subequal and subcontiguous. Median ocular quadrangle slightly longer than wide (19/17), wider in front than behind (17/16), the posterior median eyes about five-sevenths as large as the anterior median eyes. Clypeus slightly more than the diameter of an anterior median eye in height. The metatarsi of the posterior legs bear numerous long hairs. Tibia and patella IV, 8.32 mm long.

Patella of the palpus less than twice as long as the tibia, both together about three-fifths the length of the femur. Patella provided with a black lateral spur extending outward; tibia with a ventral distal process that does not touch the posterior border of the bulb.

Type locality.—China: Male holotype from Yao-Gi, Mupin, Szechwan Province, 8,000 feet, July 14, 1929; male paratype from Tatsientu, July 20, 1923. *Type:* U.S.N.M. Cat. No. 1150.

This spider bears considerable resemblance in its general structure to *Agelena labyrinthica* (L), but is immediately distinguishable from that species by the structure of the palpal organ which has an embolus that is distinct and separated from the process of the bulb.

Agelena opulenta L. Koch

Agelena opulenta L. Koch. Verh. Zool.—Bot. Gesell. Wien 27: 757, pl. XV, fig. 20. 1877.

Records.—China: Yunnan Border, 6,000 ft., October, 1928, female; Szechwan Province, Suifu, 1,000 ft., October, 1930, two females.

Coras luctuosus (L. Koch)

Coelotes luctuosus L. Koch. Verh. Zool.—Bot. Gesell. Wien 27: 752, pl. XV, figs. 14, 16, 1877.

Record.—China: Szechwan Province, Suifu, 1,000 ft., November 17, 1930, female.

Family PISAURIDAE

Dolomedes chinesus duoformus, n. subsp. Fig. 2

Female.—Total length, 17.33 mm. Carapace, 7.92 mm long, 6.44 mm wide. Abdomen, 9.20 mm long, 5.15 mm wide.

Carapace yellowish brown, lighter behind the eyes, darker about the longitudinal groove. Sides of the carapace presenting a mottled appearance having irregular lighter spots and streaks. Posterior lateral eyes situated on black spots. Clypeus with two dark lines that converge at the anterior median eyes; each of these lines extend down a chelicera as a median stripe. Labium and endites reddish yellow, sternum with a central light leaf-like design. Legs with coxae, femora, and patellae blackish mottled with yellow beneath, but reddish above as are the other joints. Abdomen brown, darker than the carapace; venter reddish, with indications of a darker median stripe that extends from the epigynum to the spinnerets.

First row of eyes longer than the second (30/26), recurved, the median eyes closer to the laterals than to each other and much larger (7/4). Second row narrower than the third (26/52). The eyes about their diameter apart, each eye seven-ninths its diameter from an anterior lateral eye. Clypeus equal in height to the length of the area formed by the first and second eye rows.

Legs moderately long, anterior tibiae with 2–2–2–2 spines below, the last pair apical. Tibia and patella I, 12.18 mm long. Tibia and patella IV, 11.88 mm long.

Type locality.—China: Female holotype from between Suifu and Yachow, Szechwan Province, 1,000 ft., June 5, 1929; two female paratypes from Yachow, Szechwan Province, 2,000 ft., July, 1928; one female paratype from Ningyuen Fu, Szechwan Province, 6,200 ft., July 31, 1928. *Type:* U.S.N.M. Cat. No. 1151.

This subspecies differs from *D. chinesus* Chamberlin in being much smaller in size, and in lacking a dorsal dark band outlined by white stripes. The epigyna, although apparently identical, differ slightly in that the median piece of *D. chinesus duoformus,* new subspecies is wider than that of *D. chinesus* Chamberlin, although the latter spider is as a whole larger in size.

Dolomedes insurgens Chamberlin

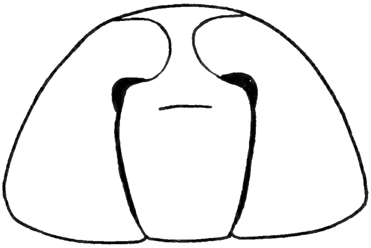
Dolomedes insurgens Chamberlin. Proc. United States Nat. Mus. 63 (art. 13) 25–26, pl. 6, fig. 41. 1924.

Records.—China: Szechwan Province, Yachow, May 1928; between Suifu and Yachow, 1000 ft., June, 5 1929, two males; Mt. Omei July, 1921, male; Suifu 2,000 ft., April 18, 1926, male.

Pisaura lama Bösenberg and Strand

Pisaura lama Bösenberg and Strand. Abh. Senckenb. Naturf. Gesell. 30: 306-307, pl. 13, fig. 340. 1906.

Record.—China: Szechwan Province, Yao-Gi, near Mupin, 8,000 ft., July 14, 1929, female.



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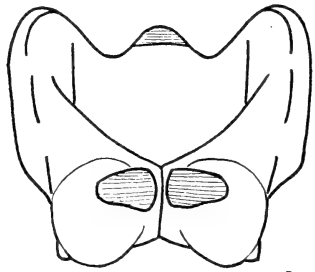

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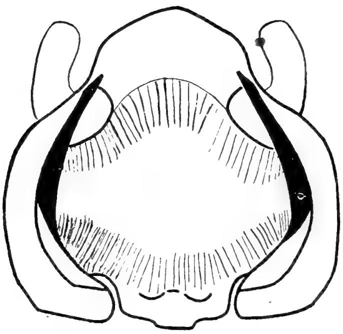

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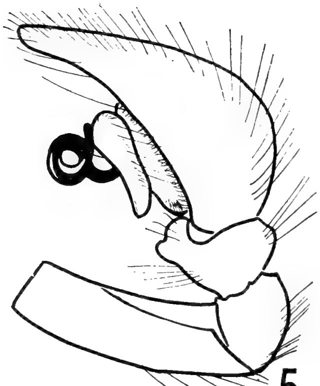

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Fig. 1.—*Heteropoda amphora*, n. sp., epigynum. Fig. 2.—*Dolomedes chinesus duoformus*, n. subsp., epigynum. Fig. 3.—*Agelena injuria*, n. sp., palpus. Fig. 4.—*Heteropoda grahami*, n. sp., epigynum. Fig. 5.—*Agelena difficilis*, n. sp., palpus. Fig. 6.—*Heteropoda virgata*, n. sp., palpus.

Family SPARASSIDAE

Heteropoda amphora, n. sp. Fig. 1

Female.—Total length, 18 mm. Carapace, 6.93 mm long, 6.43 mm wide. Abdomen, 11.00 mm long.

Carapace reddish yellow, discolored by deeper red bars or short stripes, and dark, sparsely distributed hairs. Spaces between the eyes red. Clypeus light yellow, with a reddish brown edge. Chelicerae reddish brown with darker longitudinal stripes. Coxae, sternum, and endites clear yellow, labium somewhat darker and edged with brown. Legs and palpi yellowish, femora punctuate with red beneath, bearing three large red spots, each at the base of a spine, on the prolateral surfaces; patellae, tibiae, and metatarsi darker than the femora above. Dorsum of the abdomen deep red, with indications of a lighter mark anteriorly. Venter much lighter, abruptly differentiated from the sides; it bears some indication of a darker median stripe which extends from below the genital fold nearly to the spinnerets.

First row of eyes slightly procurved, two-thirds as wide as the second row, which is slightly recurved, with the laterals on protuberances. Anterior median eyes more than a diameter apart, three-fifths of a diameter from the anterior lateral, and much smaller than these (6/13). Posterior median eyes separated from each other by more than a diameter, from the posterior lateral by almost two diameters and also much smaller than the latter (2/3). Median ocular quadrangle longer than wide (15/14), narrower in front than behind (9/14). Clypeus higher than the diameter of an anterior lateral eye (15/12). Chelicerae with four teeth on the lower margin, of which the one furtherest from the claw is the least robust, and three teeth on the upper margin, of which the middle one is the most robust. Labium slightly wider than long, and much shorter than the endites (22/55).

Posterior tibiae and metatarsi with 2–2–2 spines below, the last pair apical, metatarsi with 1–1 spines on the lateral surfaces. Anterior tibiae with 2–2–2–2 spines below, the last pair apical, anterior metatarsi also with 1–1 spines on the lateral surfaces. Trochanters notched. Epigynum chitinous, wider than long, flattened below, with the median piece oval, vase-like being constricted anteriorly.

Type locality.—China: Female holotype from between Suifu, and Yachow Szechwan Province, 1,000 feet, June 5, 1929. *Type*: U.S.N.M. Cat. No. 1152.

This spider resembles the Ceylonese species, *H. Kandiana* Pocock in having an epigynum whose median piece is linguiform, and a pale clypeus which is more or less crescentic in shape. It differs in being smaller by six millimeters, and in possessing an anterior row of eyes which is slightly procurved rather than strongly so. These similarities and differences are derived not from an examination of specimens of *H. Kandiana* Pocock themselves, but from a study of Pocock's brief descriptions.[2]

Heteropoda grahami, n. sp. Fig. 4

Female.—Total length, 12.00 mm. Carapace, 4.55 mm long, 4.45 mm wide. Abdomen, 7.52 mm long, 4.95 mm wide.

[2] Jour. Bombay Nat. Hist. Soc. **12**: 752. 1899; *The fauna of British India*, Arachnida, p. 261, 1900.

Carapace yellowish with red markings at the pars cephalica, and a darker median line which extends from between the posterior median eyes to the rear slope. Sides of the carapace with reddish streaks, and dark margins. Eyes on a red background. Clypeus light yellow; chelicerae also yellow, each with short reddish bars followed by several reddish spots. Sternum yellow with four dark marks on each side, and a larger diamond-shaped central one. Labium and endites yellowish. Legs yellow beneath, all the joints except the metatarsi and tarsi richly provided with small red spots. Femora with three large red spots on the prolateral surfaces. Dorsum of the abdomen having a yellow ground densely provided with irregular red markings, which become more dilute at the sides and venter.

The eyes in two slightly recurved rows, with the first row three-fourths as wide as the second. Anterior median eyes about two-thirds of a diameter apart, one-third of a diameter from the anterior lateral, and smaller than these (3/4). Posterior median eyes about a diameter and a third apart, about two diameters from the posterior lateral, and smaller than these (6/7). Median ocular quadrangle slightly longer than wide (20/19), narrower in front than behind (15/19). Clypeus higher than the diameter of an anterior lateral eye (5/4). Chelicerae with four teeth on the lower margin, of which the one furthest from the claw is the least robust, and two teeth on the upper margin with strong indication of a third one. Labium slightly wider than long, and much shorter than the endites (15/35).

Anterior tibiae with 2–2–2–2 spines below, the last pair apical, 1 submedian spine on each lateral surface, and 1–1 above, the first spine basal; anterior metatarsi with 2–2 spines below, 1–1 on the lateral surfaces and one above. Tibia of fourth leg with 2–2–2 spines below, the last pair apical, 1–1 on the lateral surfaces, and 1 above; metatarsus of fourth leg with 1–1–1 spines below, the last apical and reduced, 1–1–2 on the lateral surfaces, the last pair apical and reduced, none above. The third legs are like the fourth except that they lack the reduced apical apines on the metatarsi. Legs 2134. Trochanters notched.

TABLE 1.—LEG MEASUREMENTS IN MILLIMETERS

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	6.63	2.48	6.63	6.04	2.08	23.86
II	7.23	2.67	6.73	6.34	2.18	25.15
III	5.45	2.08	5.05	4.55	1.58	18.71
IV	6.44	2.18	5.15	4.74	1.98	20.49

Epigynum not chitinous in front, and open; behind expanded into two projections, which are contiguous at the bases, but widely separated distally.

Type locality.—China: Female holotype from Ningyuen Fu, Szechwan Province, July 31, 1928; immature female paratype from Yachow district, Szechwan Province, 1,800 ft., May, 1928. *Type:* U.S.N.M. Cat. No. 1153.

This spider seems to be most closely allied to the Japanese *Heteropoda aulicus* L. Koch, but differs from that species in the relationship of the eyes and in the structure of the epigynum.

Heteropoda virgata, n. sp. Fig. 6

Male.—Total length, 10.49 mm. Carapace, 5.45 mm long, 4.75 mm wide. Abdomen, 4.95 mm long, 2.97 mm wide.

Carapace clear reddish brown with darker streaks at the sides. Sides of the carapace, clypeus, and chelicerae lighter. Sternum, labium, and endites orange. Legs clear yellow. Dorsum of the abdomen reddish brown, sides lighter. Venter pale, outlined by a dark line on each side which extends from the genital fold almost to the spinnerets.

First row of eyes straight or slightly procurved, three-fourths as wide as the second row, which is slightly recurved, with the laterals on protuberances. Eyes of the first row about equidistant, the median smaller than the lateral (3/4). Posterior median eyes separated from each other by about a diameter, from the posterior lateral by more than a diameter (11/7), and smaller than these (6/7). Median ocular quadrangle longer than wide (18/21), narrower in front than behind (15/18). Clypeus about as high as the diameter of an anterior lateral eye. Chelicerae with four teeth on the lower margin, of which the one furthest from the claw is the least robust, and three teeth on the upper margin, of which the middle one is the most robust. Labium wider than long (18/15), and much shorter than the endites (15/38).

Anterior tibiae with 2–2–2–2 spines below, the last pair apical, 1 spine laterad, 1–1 above, the first spine basal; anterior metatarsi with 2–2 spines below, 1–1 laterad. Tibia of the fourth leg with 2–2–2 spines below, the last pair apical, 1–1 laterad, 1 above; metatarsus of the fourth leg with 1–1–1 spines below, 1–1–2 laterad. The third leg like the fourth except that it lacks the reduced distal spines on the metatarsus. Legs 2143, trochanters strongly notched.

TABLE 2.—LEG MEASUREMENTS IN MILLIMETERS

	Tr.&Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	6.83	2.57	6.24	6.92	2.48	25.04
II	7.72	2.67	6.83	7.03	2.57	26.82
III	6.53	2.18	5.34	6.14	1.88	22.07
IV	6.72	2.28	5.54	6.83	2.13	23.55

The tibia of the palpus bears a hooked projection which is almost as long as the tibia itself.

Type locality.—China: Male holotype from between Suifu and Yachow, Szechwan Province, 1,000 ft., June, 1929. *Type:* U.S.N.M. Cat. No. 1154.

The unusually small size and glabrous condition of this spider together with the structure of the palpus, which is shown in Figure 6, will immediately distinguish it from other oriental species.

Heteropoda forcipata (Karsch)

Sarotes forcipatus Karsch Berliner Entom. Zeitschrift **25:** 38. 1881.

Records.—China: Szechwan Province, near Mupin, 3,000 ft. July 1, 1929,

female; Suifu, 1922, female; Washan, 2,000 ft., July 18, 1925, female; Ning-yuen Fu, July 31, 1928, female.

Heteropoda venatoria (Linnaeus)

Aranea venatoria Linnaeus Syst. Nat., 12th ed., p. 1035. 1767.

Records.—China: Szechwan Province, Washan, 2,000 ft., July 18, 1925, female; Suifu, 1922, female; April, 1924, female; April, 1928, two females; March 15, 1929, female.

ICHTHYOLOGY.—*Description of a new flatfish, with notes on related species.*[1] ISAAC GINSBURG, Bureau of Fisheries. (Communicated by WALDO L. SCHMITT.)

An extensive study of the American species of flatfishes belonging to the genus *Paralichthys* and the closely related genera *Hippoglossina* and *Pseudorhombus*, was carried out by me recently. Since the publication of the final report is likely to be delayed for some time, some of the more interesting results of that study, as well as a description of a new species, are published here separately.

Certain errors in the systematics of the species under consideration have been repeated for years and have acquired the weight of tradition. Nevertheless, the morphological facts compel me to break away from tradition. In a recent valuable book on the systematics of the flatfishes by Norman,[2] which is bound to be used as a standard book of reference by students of flatfishes in the years to come, a number of these errors are included. The most important of such current errors are here corrected.

The three genera under consideration were incompletely separated heretofore, and as a consequence some of the species were referred to genera to which they do not belong. The only substantial character which has been used for distinguishing *Pseudorhombus* from *Paralichthys* and *Hippoglossina* was the presence or absence, or the relative development, of the anterior branch of the lateral line. This character was used by previous authors and its use is continued by Norman.

However, this character only incompletely separates the groups of species. In the smaller Indo-Pacific species, which belong to *Pseudorhombus*, this accessory branch is *generally* better developed, reaching the dorsal profile, while in the American species it is usually not as

[1] Published by permission of the U. S. Commissioner of Fisheries. Received December 30, 1935.

[2] NORMAN, J. R. *A systematic monograph of the flatfishes (Heterosomata).* Vol. 1. *Psettodidae, Bothidae, Pleuronectidae.* British Museum, London, 1934.

well developed; but this is not always true. In some species of *Pseudorhombus* the accessory branch is not better developed than in most American species; and in *californicus*, the genotype of *Paralichthys*, it is often well developed, reaching or nearly reaching the dorsal profile. Although these facts are shown in part by the outline figures published by Norman, he continues the use of this character in his key which is thus not entirely in accord with his own figures. As a matter of fact, the use of this character as the basis for the major division of the three genera leads to false conclusions. During my studies it was determined that the presence or absence of accessory scales constitutes a valuable character for the major division of the species into natural groups. Although this character was neglected heretofore, its use leads to a more natural classification of the species.

KEY TO THE GENERA

a. Accessory scales absent.
  b. Eyeball and orbit very large to moderately large, interorbital reduced to a mere ridge and origin of dorsal more or less behind anterior margin of eye; the three characters always occurring together. Anterior accessory branch of lateral line often rather poorly developed...*Hippoglossina* Steindachner
  bb. Eyeball and orbit usually small or moderate, sometimes moderately large; interorbital usually wider than a mere ridge, sometimes reduced to a narrow ridge; origin of dorsal usually in front of anterior margin of eye, sometimes behind its anterior margin; sometimes approaching *Hippoglossina* in one or another of these characters, but the three usually not occurring together. Accessory branch of lateral line usually but not always reaching dorsal profile......*Pseudorhombus* Bleeker
aa. Accessory scales always present, except in small specimens, their appearance with respect to size differing with the species...*Paralichthys* Girard

By the use of the above synopsis *Paralichthys* may in practice be distinguished satisfactorily, except for the smaller specimens; but much remains to be desired with respect to the separation of *Hippoglossina* and *Pseudorhombus*. The characters given in the key are the best known at present for separating those two genera, and judging solely by these characters, the best course would seem to be to unite them. However, each one of the two groups of contained species has a distinctive physiognomy and it seems highly probable that further study will reveal more satisfactory characters for separating them. Current usage is therefore continued and the two genera

are recognized as distinct for the time being. No matter how limited the synopsis may be for use in practice, it evidently groups the species in accordance with their true natural relationship.

Hippoglossina mystacium, n. sp. Fig. 1

Description.—On eyed side scales ctenoid on body; mostly cycloid on head, but many weakly ctenoid scales present. On blind side, ctenoid scales present on posterior part of body, the ctenoid scales extending on midline to a distance behind arch about equal to 1/2 of its chord; scales on head and on body anteriorly cycloid. Scales in 52 rows over straight part of lateral line to end of hypural; 28 perforate scales in arch; 26 rows in a chord subtending the arch. Three cycloid, embedded scales on maxillary. Accessory scales absent. Gill rakers, 3 comparatively long ones on upper limb, with

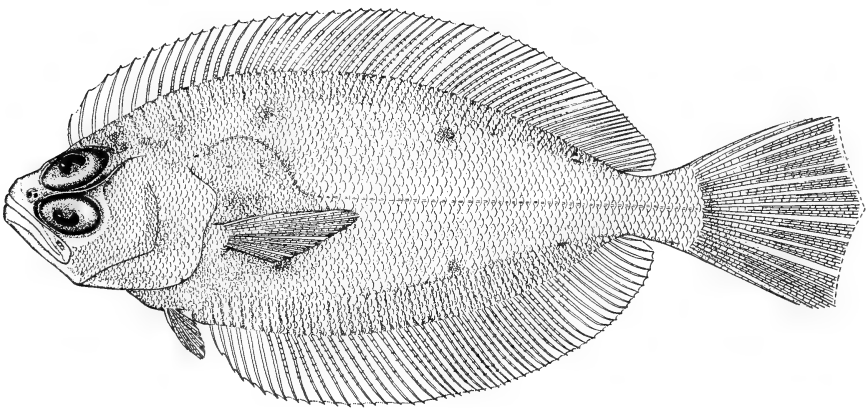

Fig. 1.—*Hippoglossina mystacium,* n. sp. Length of specimen 18.3 cm. Drawn from the type by Louella E. Cable.

2 widely spaced and very small ones above; 12 on lower limb (same on both sides). Anal rays 55; dorsal rays 66; pectoral rays 11 on eyed side, 10 on blind side. Origin of dorsal nearly over middle of eye. Eye notably large; interorbital a mere ridge. Anterior teeth but slightly enlarged. Maxillary extending to a vertical through posterior margin of pupil, conspicuously narrow posteriorly. Sinistral.

Color nearly faded, traces of 6 spots in 2 lengthwise rows present, like in the other species of the genus, somewhat nearer to upper and lower profiles than to straight part of lateral line, every spot in either row placed on a transverse line with its fellow in the other row; first pair of spots on a transverse line through about middle of arch in lateral line, second pair on a vertical somewhat nearer to head than to base of caudal, third pair not far from ends of dorsal and anal fins; traces of smaller spots on caudal peduncle, one each near upper and lower posterior angles, at base of caudal rays, these two spots being continued to a slight extent on blind side.

Measurements of type.—Total length 183 mm. Standard length 146.5 mm. Greatest depth 39.8, least depth of caudal peduncle 9.5, head 30.7, length of maxillary 13.6, greatest width of maxillary 3, orbit 10.4, eyeball 8.5, snout (to margin of upper orbit) 6.5, left pectoral 17.9, right pectoral 13.1,

left ventral 9.1, right ventral 8.8, caudal 24.9, and straight part of lateral line 57.1% of standard length. Length of chord subtending arch in lateral line 3.6 times in straight part; length of a vertical from chord to apex of arch 3.2 times in arch.

Holotype.—U.S.N.M. 77393, near Taitao Peninsula, Chile; Albatross Station 2787; lat. 46°47′30″ S., long. 75°15′ W.; 61 fath.; Feb. 9, 1888.

Comparison.—The nearest relatives of this species are *Hippoglossina stomata* Eigenmann and Eigenmann, *H. bollmani* Gilbert and *H. macrops* Steindachner. The specimen described was directly compared with specimens of the former two species, including their types; but for its comparison with *macrops,* I had to rely on the original account. It is most closely related to *stomata,* differing in having a shorter and narrower maxillary, and a shorter head. It further differs in that the maxillary is almost bare of scales, while that of *stomata* has a small patch of ctenoid scales. The present species is more remotely related to *bollmani.* It differs strikingly from *bollmani* in having more numerous gill rakers, and the anal rays are also more numerous. The number of scales and dorsal rays falls near the upper end, but outside the frequency distribution of that of *bollmani.* The ctenoid scales on the blind side extend more forward in *bollmani.* The body is deeper than in *bollmani;* but the two species approach closely in the length and width of the maxillary and the length of the head. As compared with the description of *macrops,* the present species has a shorter head, a more slender body and the ctenoid scales on the blind side extend more forward.

Hippoglossina oblonga (Mitchill)

This species from the east coast, which is common enough to enter the commercial catch, although its market possibilities are limited by its comparatively small size, has been placed universally, except by the early authors, in *Paralichthys.* However, unlike all species of *Paralichthys* it lacks accessory scales. In this it agrees with the species of *Hippoglossina.* Also, it always has some ctenoid scales on the blind side, a character normally present in most species of *Hippoglossina* but not in those of *Paralichthys,* except to some slight extent in infrequent individual variants. Furthermore, this species has a very narrow interorbital, a comparatively large eye and relatively small teeth, nearly agreeing with the species of *Hippoglossina* in these respects and unlike all species of *Paralichthys.* It is evident that this species is congeneric with the other species of *Hippoglossina.*

H. oblonga is evidently most nearly related to *Lioglossina tetrophthalmus* Gilbert from the west coast. After placing it where it properly belongs in the system, the boundary hitherto drawn between the genera *Lioglossina* and *Hippoglossina* largely breaks down, although they may be recognized as subgenera.

Pseudorhombus isosceles (Jordan)

This species likewise lacks accessory scales and has ctenoid scales on the blind side, and consequently must be removed from *Paralichthys.* It fairly agrees with the other species of *Pseudorhombus* and is the only known American representative of that genus. This species, the genotype of *Tarphops,* and four other Indo-Pacific species have ctenoid scales on the blind side. Judging by the morphology of the species of these three closely related genera, this character forms a more adequate and natural basis for separation than the number of scales. It would seem, therefore, desirable on grounds of morphology to rearrange the species of *Tarphops* and *Pseudo-*

rhombus and place them in two subgenera based on the presence or absence of ctenoid scales on the blind side. In that case, *isosceles* will fall in the subgenus *Tarphops*.

Paralichthys triocellatus Miranda Ribeiro, judging by the original account, is probably a synonym of *isosceles*. Four specimens of a flounder obtained at Cape Frio, Brazil, by the *Terra Nova* and recorded by Regan as *Paralichthys oblongus* are described and figured by Norman (op. cit., p. 80), and referred to *triocellatus*. Norman describes these specimens as having cycloid scales on the blind side. If *triocellatus* is in fact a synonym of *isosceles*, the four specimens forming the basis of Norman's account must represent an unnamed species. Even if *triocellatus* is distinct from *isosceles*, Norman's specimens evidently have fewer scales than Miranda Ribeiro's fish and they probably represent a new species anyway.

Paralichthys patagonicus Jordan and Goss

This species is placed by Norman in the synonymy of *vorax* (his *brasiliensis*). However, it has ctenoid scales on the eyed side and is entirely distinct from that species. *P. bicyclophorus* Miranda Ribeiro which Norman recognizes, is possibly a synonym of *patagonicus*. At least, the original account of *bicyclophorus* fails to show how it differs from this species.

Paralichthys brasiliensis (Ranzani)

Something may be said about the nomenclature of this and another species. Norman resurrects a name out of the synonymy and designates this species as *P. orbignyana* (Valenciennes), and uses the name of *brasiliensis* for an entirely different species, although he apparently did not examine the types on which either one of those two names were based. This shifting about of the names of species, one of them well established, seems unfortunate. This is a common species on the coast of Brazil which has been described and recorded a number of times by American authors to whom it was known for more than half a century under the name of *brasiliensis*. There are those biologists who claim that a well established name should be retained regardless of priority and there are some cogent arguments which may be advanced in favor of that contention. Without discussing the pros and cons of this proposition, I think that it will be generally admitted that, at least, a well established name is not to be changed unless good and sufficient reasons are advanced for the change. In the present case the only way of definitely determining the question is by a reexamination of the types of both, *brasiliensis* and *orbignyana*, since the original accounts are not sufficient to identify the particular species. Pending such study I continue the use of the well established name *brasiliensis* for this species. Judging by the material in the U. S. National Museum and that recorded by Norman in the British Museum, the present species is much more common than the following. Considering probabilities alone, therefore, the chances are much greater that Ranzani had specimens of the present species.

Paralichthys vorax (Günther)

American writers have generally placed the name *vorax* in the synonymy of their *brasiliensis;* while Norman who designates the *brasiliensis* of American authors as *orbignyana*, describes this species under the name of *brasiliensis*. We thus have a nice, and possibly unnecessary confusion of names. Norman, who studied the types of *vorax*, correctly distinguishes this species from the *brasiliensis* of American authors.

It is remarkable that in the structural characters which I studied in detail, such as the number of gill rakers, fin rays, scales and proportional measurements, this species agrees or very nearly agrees with *albigutta* from the east coast of the United States, although the geographic ranges of the two species are widely discontinuous. The only substantial difference is found in the color, *vorax* lacking the ocellated spots characteristic of *albigutta*.

There is only one specimen of this species in the U. S. National Museum. Norman records only two specimens, the types, in the British Museum. That author also lists with a query one large, stuffed specimen from Fort Famine, Magellan Strait. This is apparently the same specimen which Günther described as *Pseudorhombus dentatus,* stating that the scales are "minutely ciliated." The presence or absence of ctenoid scales in large specimens is always a good specific character in *Paralichthys*. This specimen, therefore, represents either *patagonicus* or an unnamed species.

Paralichthys lethostigma Jordan and Gilbert

Norman evidently did not well separate his material of *Paralichthys* from the east coast of the United States. The specimen from Beaufort, North Carolina, which he records under this species is an unusually slender example of *albigutta*. The specimen which Norman lists from Tobago can hardly be a *lethostigma* considering the comparatively limited geographical distribution of the species of *Paralichthys*. It may likely prove to be an example of *P. tropicus* Ginsburg which is very near in its structural characters to *lethostigma*. The counts of the dorsal and anal rays given by Norman for *lethostigma* range too low. This is evidently due to his inclusion of some *albigutta* material in his account. The frequency distributions of these counts are very nearly the same in *dentatus* and *lethostigma*.

The species of *Paralichthys* are not easy to distinguish. Nevertheless, if frequency distribution tables of the more important specific characters are prepared, and the several characters of any given specimen are compared with such tables, it becomes a relatively easy matter to refer with assurance individual fish to their proper species. Such tables of the scale, gill raker, and fin ray counts, and comparative tables of proportional measurements are included in my manuscript.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

38TH ANNUAL MEETING

The 38th Annual Meeting of the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, January 16, 1936, with 45 members present. President McCoy called the meeting to order at 9:05 P.M.

The minutes of the 37th Annual Meeting were read and approved. The Corresponding Secretary, Dr. Paul E. Howe, submitted the following report on the membership and activities of the Academy:

Membership: During the year 1935, 18 persons were elected to regular membership, 15 of whom had accepted and qualified for membership before the end of the year. One was elected to honorary membership: Dr. Jules Schokalsky, Leningrad, U.S.S.R., in recognition of his distinguished contributions to physical geography, oceanography and meteorology.

Sixteen resignations were accepted, of which 11 were resident and 5 nonresident members. The Academy lost by death 14. The net loss in membership was therefore 15 or 2.7 per cent.

The members of the Academy stood in respect as the Secretary read the names of those lost by death.

Members:
- William H. Burr, New York, New York, December 13, 1934.
- Joseph H. Bryan, Washington, D. C., February 3, 1935.
- Edward S. Dana, New Haven, Connecticut, June 16, 1935.
- Leon Dominian, Montevideo, Uruguay.
- Marion Dorset, Washington, D. C., June 14, 1935.
- Ernst G. Fischer, Washington, D. C., September 22, 1935.
- Daniel R. Harper, Washington, D. C.
- Albert S. Hitchcock, Washington, D. C., December 16, 1935.
- Walter Hough, Washington, D. C., September 20, 1935.
- A. Bruce Macallum, London, Ontario, Canada, April 4, 1934.
- David K. Shute, Washington, D. C., October 21, 1935.
- (Charles) David White, Washington, D. C., February 6, 1935.

Patron:
- Henry C. Perkins, Washington, D. C.

Honorary Member:
- Johannes Schmidt, Copenhagen, Denmark.

On January 1, 1936, the membership consisted of 14 honorary members, 3 patrons, and 522 members, one of whom was a life member. The total membership was 539, of whom 387 reside in or near the District of Columbia, 131 in other parts of the United States, and 21 in foreign countries.

The numerical index which the Secretary in previous reports has called the "index of rate of loss of interest" in the organization on the part of its

members as measured by the number per year per hundred who resign or are dropped, has the value of 2.7 per cent for 1935.

The Board of Managers held five meetings with an average attendance of 12. The 29th edition of the Red Book was published during the year.

The Academy was represented by Dr. A. S. HITCHCOCK at the International Botanical Congress held in Amsterdam in September, 1935.

The Recording Secretary presented the following report:

The 38th year of the Academy began with the 262nd meeting and ended with the 268th meeting. Of these seven meetings, two were joint meetings, one with the Medical Society, one with the Philosophical Society. All were held in the Assembly Hall of the Cosmos Club.

The 262nd meeting was held on Friday, February 15, 1935, with about 70 persons present. President McCOY introduced the speaker, retiring president L. B. TUCKERMAN, who addressed the Academy upon *Fiction in measurement.*

The 263rd meeting was held March 8, 1935, with about 40 persons present. Mr. W. M. CORSE presided and introduced Principal CHARLES A. EDWARDS of the University College, Swansea, Wales. The title of his address was *Science, education and industry: whither drifting?*

The 264th meeting was held on Thursday, March 21, 1935, with about 125 persons present. Past-president L. B. TUCKERMAN introduced Professor RAYMOND PEARL, of Johns Hopkins University, who spoke upon *Biology and human trends.*

The 265th meeting was held Thursday, April 18, 1935, with 42 persons present. Vice-president J. F. COUCH introduced RUSSELL S. McBRIDE, who spoke upon *The service and failures of chemistry in the advancement of civilization.*

The 266th meeting was held jointly with the Medical Society of the District of Columbia on November 21, 1935, with about 100 persons present. President McCOY introduced Col. P. M. ASHBURN, M.D., who spoke upon *The medical history of the conquest of the Americas in the 16th and 17th centuries.*

The 267th meeting was held jointly with the Philosophical Society on Thursday, December 19, 1935, with 70 persons present. President McCOY introduced Dr. SANFORD V. LARKEY, Librarian of the Welch Memorial Library of Johns Hopkins University, who spoke upon *The role of scientists in the Elizabethan Government.*

The 268th meeting was held on January 16, 1936, with about 110 persons present. Vice-president O. H. GISH introduced the retiring president, Dr. GEORGE W. McCOY, who spoke upon the *Comings and goings of epidemics.* At the end of the meeting, the vice-president declared a recess preceding the 38th Annual Meeting.

The report of the Treasurer, H. G. AVERS, was read by Mr. HOWARD S. RAPPLEYE:

CASH RECEIPTS AND DISBURSEMENTS

Receipts				
From Back Dues		$ 265.00		
From Dues for 1935		2,390.00		
From Dues for 1936		30.00		
From Subscriptions for 1935		743.60		
From Subscriptions for 1936		281.40		
From Sales of Journals		102.87		
From Payments for Reprints		238.83		
From Sales of 1932 Directory		1.80		
From Sales of 1935 Directory		41.70		
From Interest on Deposits		25.27		
From Interest on Investments		1,459.70		
Total receipts			$5,580.17	
Cash Balance January 1, 1935			2,526.54	
To be accounted for				$8,106.71
Disbursements				
For Secretary's Office		$ 290.35		
For Treasurer's Office 1934		2.25		
For Treasurer's Office 1935		226.88		
For Journal Office, 1934		46.94		
For Journal Office, 1935		324.72		
For Journal Printing, 1934		384.65		
For Journal Printing, 1935		2,753.24		
For Reprints		495.83		
For Illustrations		360.46		
For Meetings Committee, 1934		20.00		
For Meetings Committee, 1935		201.50		
For Directory		629.37		
Bank Debit Memos, as follows:				
Dues	$0.35			
Subscriptions	.11			
Sales of Journals	.50			
Reprints	.35			
Int. on Investments	.44	1.75		
Total Disbursements			$5,737.94	
Cash Balance December 31, 1935			2,368.77	
Total				$8,106.71

Note: Of the above expenditures, the amount of $453.84 was paid covering bills chargeable to 1934.

He listed the investments of the Academy as totalling $21,096.37.

The Auditing Committee, Howard S. Rappleye, W. H. Bradley and James F. Couch, reported:

"The Treasurer's records of receipts and expenditures as shown in his account books and included in his report have been examined and found correct. All vouchers have been examined and found to be correct and properly approved. The balance sheets submitted by the bank and the securities listed in the Treasurer's report have been examined. The statement of the assets of the Academy was found correct. The records of the Treasurer's Office have been carefully and systematically kept, thus greatly facilitating the work of the Auditing Committee."

The Board of Editors, JOHN A. STEVENSON, F. G. BRICKWEDDE and ROLAND W. BROWN, submitted the following report covering the publication of Volume 25 of the Journal for the year 1935:

"Volume 25 consisted of 588 pages, including an eight-page index. This compares with 576 pages in 1934, 588 in 1933, 572 in 1932, and 552 in 1931. It contained 75 original papers as contrasted with 78 in 1934, 77 in 1933, and 79 in 1932. Thirty-seven papers were by members of the Academy, and 38 were communicated of which latter number several were by authors who became members of the Academy after the date of receipt of their papers. Original papers were illustrated by 73 line cuts and 10 half-tones. Excess cuts illustrating several papers were paid for by the respective authors. Space in the volume was distributed among the different sciences, as follows:

	Pages
8 papers on Physics, including Geophysics and Seismology	106.8
4 papers on Chemistry	15.20
2 papers on Crystallography	14.20
3 papers on Pharmacology	11.6
9 papers on Geology, including stratigraphy and hydrology	40.55
10 papers on Paleontology, including paleobotany	34.15
2 papers on general Biology	24.7
17 papers on Botany	87.20
10 papers on Zoology	83.40
9 papers on Entomology, Ornithology and Conchology	35.20
1 paper on Psychology	14.35

Proceedings of the Academy and affiliated societies occupied 54.7 pages, as follows:

The Academy	2.65
Anthropological Society	1.35
Botanical Society	11.10
Geological Society	24.45
Philosophical Society	15.15

Scientific notes and news, and obituaries occupied the remaining 47 pages.

As in 1934, scientific notes and news as supplied by Science Service were used to the extent of approximately four pages per number, space given to original papers permitting. Acting upon the recommendation of the Board of Editors, the use of news notes was dispensed with by the Board of Managers at the end of the calendar year. The number of papers in the biological field presented for publication was approximately the same as in the preceding year so that further effort has been made to obtain papers in the field of the physical sciences. The JOURNAL is, relatively speaking, up-to-date with manuscripts submitted to it.

The cost of printing, wrapping, mailing and postage was \$4.59 per printed page; illustrations 70 cents per page; alterations 10 cents per page; and reprints 84 cents per page. Of this latter amount approximately one-half was paid for by the respective authors. The cost of the News Service was \$300. Exclusive of the cost of the News Service and reprints, the total cost per page for printing the Journal was approximately \$5.20, a slight reduction over last year's cost."

The Board of Tellers, George A. Greenbank, W. H. Bradley and L. V. Judson, reported the election of the following officers: President, O. E. Meinzer; Non-resident Vice Presidents, Paul D. Foote, Pittsburgh, Pennsylvania, and P. C. Standley, Chicago, Illinois; Corresponding Secretary, Nathan R. Smith; Recording Secretary, Charles Thom; Treasurer, H. G. Avers; Board of Managers, Paul E. Howe and H. L. Dryden.

The Corresponding Secretary read the list of nominations for vice-president submitted by the affiliated societies as follows:

Philosophical Society of Washington, Francis B. Silsbee
Anthropological Society of Washington, F. H. H. Roberts
Biological Society of Washington, Chas. E. Chambliss
Washington Section, American Chemical Society, James H. Hibben
Entomological Society of Washington, A. H. Clark
National Geographic Society, Frederick V. Coville
Geological Society of Washington, W. T. Schaller
Medical Society of the District of Columbia, H. C. Macatee
Columbia Historical Society, Allen C. Clark
Botanical Society of Washington, Charles Drechsler
Archaeological Society of Washington, Ales Hrdlicka
Washington Section, Society of American Foresters, S. B. Detwiler
Washington Society of Engineers, Paul C. Whitney
Washington Section, American Institute of Electrical Engineers, H. G. Dorsey
Washington Section, American Society of Mechanical Engineers, H. N. Eaton
Helminthological Society of Washington, Emmett W. Price
Washington Branch, Society of American Bacteriologists, H. W. Schoening
Washington Post, Society of American Military Engineers, C. H. Birdseye
Washington Section, Institute of Radio Engineers, Louis Cohen

By vote of the Academy, the Recording Secretary was instructed to cast one vote for the list as read and the vice-presidents were declared elected.

President McCoy appointed Past Presidents W. J. Humphreys and L. B. Tuckerman to escort President-elect Meinzer to the chair. President Meinzer took over the gavel and addressed the Academy briefly.

Adjournment followed at 9:45.

Charles Thom, *Recording Secretary*

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OF THE

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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JOURNAL

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VOL. 26 APRIL 15, 1936 No. 4

ASTRONOMY.—*Simon Newcomb, 1835–1909.*[1] EDGAR W. WOOLARD, United States Weather Bureau.

Two and a half centuries ago, Sir Isaac Newton presented convincing evidence that the force which holds the moon in its orbit is identical with the force that causes unsupported bodies near the surface of the earth to fall, and that this force conforms to the inverse square law. On the basis of this evidence and Kepler's empirical laws of planetary motion, Newton proposed the hypothesis of Universal Gravitation. From the general Laws of Motion (also formulated by Newton on the basis of his own and Galileo's work) and the Law of Gravitation, developed Celestial Mechanics, one of the greatest achievements of the human intellect.

The problems of celestial mechanics have always been a constant challenge and a source of inspiration to the mathematician and to the astronomer; and among those who have contributed to this difficult and intricate subject, will be found some of the most illustrious names in the history of the mathematical sciences. Among the select few who have been outstanding masters of the field, none ranks higher than Simon Newcomb, the one hundredth anniversary of whose birth occurred in 1935.

Simon Newcomb was one of the most notable men of science that America has ever produced; and his life cannot fail to be an inspiration to others—it is a story of boyhood dreams and ambitions, fulfilled by patient and persevering self-effort. He early formed the conviction that one should choose that sphere in life to which he was most strongly attracted and for which his faculties best fitted him. He himself was irresistibly attracted to celestial mechanics; it seemed to him to embody the highest intellectual power to which man had ever attained—from merely the positions of the celestial bodies in the sky, as observed from night to night, and on the basis of the single fact that each of these bodies is attracted by all the others, as stated

[1] Presented before the Maryland-District of Columbia-Virginia Section of the Mathematical Association of America, College Park, Md., December 7, 1935. Received December 17, 1935.

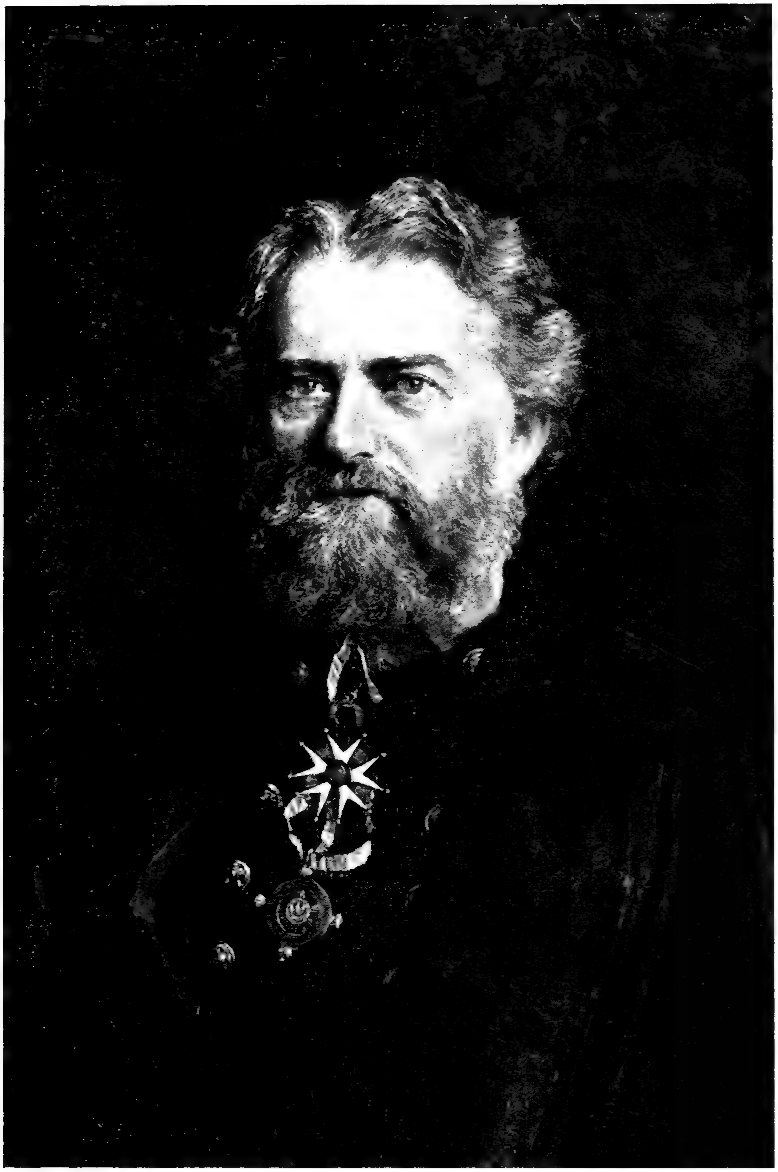
by the law of gravitation, the astronomer is to weigh these mighty bodies, determine the vast orbits in which they are moving in space, predict their majestic motions during future time, determine what changes of form and position their orbits will undergo through countless ages, make maps showing exactly over what cities and towns on the surface of the earth the shadow of the moon, during an eclipse of the sun, will pass fifty years hence or over what regions it passed centuries ago. To thousands of men who could achieve success and wealth in almost any walk of life, to hundreds who could wield empires, there would be but one who could succeed with this impressive problem—those who have done it are the select few of the human race—"Nearer the gods no mortal may approach."

Simon Newcomb was born March 12, 1835, at Wallace, on the north coast of Nova Scotia; the centenary of his birth was appropriately commemorated on August 30, 1935, when a cairn erected by the Historic Sites and Monuments Board of Canada was unveiled there by his daughter, Mrs. Joseph Whitney, of Washington, D. C., in the presence of many notable officials.

Newcomb's father was a country school teacher, an occupation which in those days meant an almost nomadic life, and Newcomb's childhood and boyhood were spent in various parts of Nova Scotia and Prince Edward Island. He was unusually strong of body, mind, and character, rather precocious, and had a conquering power of mental concentration. He received very little formal schooling; when he attended his father's school at all, he came and went with entire freedom, but he knew the alphabet at the age of 4, began arithmetic at 5, and geography at 6. He avidly read a work on astronomy before he was 10 years old, and was greatly attracted by the subject. Without the guidance of an instructor, he eagerly studied algebra, natural philosophy, and navigation, mostly from old books that had belonged to his grandfather; and he became enraptured with Euclid at the age of 15.

He was uncommonly deficient, however, in skill at any kind of manual labor, particularly that required on a farm; and because of the conditions of life at that time and place, this shortcoming, combined with the lack of appreciation by the people around him of his taste for learning, made his boyhood one of sadness. From reading, he gradually formed a vague conception of a different world—"a world of light," as he expresses it in his *Reminiscences*,[2] "where dwelt men

[2] Simon Newcomb. *Reminiscences of an astronomer.* Boston. 1903.



Simon Newcomb

who wrote books, and people who knew men who wrote books, where lived boys who went to college and devoted themselves to learning"—and he longed to get into this world. No possibility of doing so presented itself, however; and circumstances led him to apprentice himself at the age of 16 to a physician of Moncton, New Brunswick.

Newcomb soon discovered that this physician was only a dishonest quack, from whom he could obtain nothing; and after two wasted years, he made his escape by running away. After a painful and difficult month, he finally reached Salem, Massachusetts, where he was met by his father who had meanwhile sought his fortune in the United States after the death of Newcomb's mother. His father finally located in eastern Maryland; and here at the beginning of 1854, Newcomb, at the age of 19, became a country school teacher. He seems to have been successful in that work, though he writes that, looking back, he is deeply impressed with the good nature of the people in tolerating him in the position.

While teaching, he spent every spare hour studying all the books on mathematics and astronomy that he could secure or to which he could gain access, inclusive of Newton's *Principia.* He frequently visited the city of Washington during the next few years. Here he went as far as the gate of the Naval Observatory, and looked wistfully in, but feared to enter. He heard for the first time of the Smithsonian Institution, and its library proved to be a rich attraction; in May, 1856, he got permission to climb into the gallery of this library and see the mathematical books. "Here I was delighted to find the greatest treasure that my imagination had ever pictured—a work that I had thought of almost as belonging to fairyland. And here it was right before my eyes—four enormous volumes—'*Mécanique céleste,* by the Marquis de Laplace, Peer of France; translated by Nathaniel Bowditch, LL.D., Member of the Royal Societies of London, Edinburgh, and Dublin'." He secured special permission to take with him the first volume of this great work of which he had so long been dreaming, and he carried it in triumph to his little schoolhouse; he found most of it quite beyond his powers at the time, but this fact served only as an incentive to continued effort.

In 1855, when 20 years old, Newcomb published his first paper: A correspondent of a newspaper had written a long letter to refute the Copernican theory; the arguments, though wholly fallacious, seemed to Newcomb to appear so plausible that he was much alarmed lest the world's belief in the Copernican doctrine be severely weakened, and so he hastened to the rescue with an answer pointing out

the fallacies. His name in capital letters printed at the bottom of his article filled him with a sense of temerity at having perhaps intruded where he might not be wanted; but it brought him the presentation of a book of *Tables and formulae* from Col. Abert, and a letter from J. Lawrence Smith (afterward a member of the National Academy) transmitting a copy of a pamphlet on a theory of the origin of meteorites, and asking Newcomb's opinion on the subject. "I had not yet gotten into the world of light. But I felt as one who, standing outside, could knock against the wall and hear an answering knock from within."

Newcomb soon became acquainted with Joseph Henry, Secretary of the Smithsonian Institution, and with J. E. Hilgard, assistant in charge of the Coast Survey; he had never before looked upon a real live person of eminence in the scientific world, and had often wondered whether there were any possibility of making the acquaintance of so great a man as Joseph Henry. His reception by Henry and Hilgard was most delightful; and it was through their interest that he secured an appointment, when not quite 22 years old, as computer in the office of the American Ephemeris and Nautical Almanac, then located at Cambridge, Mass. Newcomb writes in his *Reminiscences:* "I date my birth into the world of sweetness and light on one frosty morning in January, 1857, when I took my seat between two well-known mathematicians [Joseph Winlock and John D. Runkle] before a blazing fire in the office of the 'Nautical Almanac'." His impressions of Henry and Hilgard, and of Winlock and others in the Almanac Office, were fully up to the most sanguine of his boyhood conceptions of men of science.

His duties required five hours a day, and his salary was $30 a month. He enrolled as a student of mathematics in the Lawrence Scientific School in Harvard College, studying under Benjamin Peirce, and received the B.S. degree the following year.

Newcomb was not satisfied at the prospect of doing nothing more than make routine calculations with formulae prepared for him by others; indeed, not yet having mastered the *Mécanique céleste,* he was almost disappointed to find that he was considered qualified for a position in the Nautical Almanac Office, but he consoled himself with the reflection that the ease of the work would not prevent him from working his way up. From this beginning he rose rapidly to a position of commanding eminence in mathematical astronomy, perhaps the most difficult field of human knowledge; and except for the one year at Harvard, he was self-taught. His original contributions

to celestial mechanics had already begun when his paper *On a method in dynamics,* dated April 2, 1858, appeared in Gould's *Astronomical Journal;* and his productivity continued uninterruptedly from that time to his death, 51 years later.

On October 7, 1861, Newcomb was appointed professor of mathematics in the U. S. Navy, for service at the Naval Observatory in Washington. His tastes and talents were in mathematical, rather than observational, astronomy; and he had applied for this position (on the recommendation of B. A. Gould, the first leading astronomer whose acquaintance he had made) only because it was desirable to provide for the future. He was without any experience or knowledge of astronomical observing; but he applied himself with diligence, and the results of his work with several different instruments during the next 10 years give abundant evidence of his energy and ability as an observer, and his remarkable breadth of view and power in planning and executing systematic and effective observing programs and in reducing and discussing the observations. There is no doubt that his experience in observational astronomy was of great value in his later theoretical work; he was unequaled in the comparison of theory with observation, and in the deduction of valuable results from large masses of data.

Newcomb's observational work did not wholly cease until about 1875; but several years previous to that time, the discrepancies between the observed positions of the moon and the positions computed from Hansen's Lunar Tables had become a serious matter; and at Newcomb's request, he was relieved from regular observing duties about the end of 1869, in order to conduct an investigation into the motion of the moon. The Lunar Theory developed into the leading interest of his life, and it received his best efforts during much of the time from 1870 to his death.

In 1877, Newcomb was appointed Director of the Nautical Almanac, and held that position until his retirement, devoting himself to mathematical astronomy which he had most at heart. It is impossible here even to mention all of his leading contributions to celestial mechanics and his many invaluable services to astronomy, to say nothing of his comparatively minor contributions, and his interests and activities in other fields; the complete bibliography of his writings[3] contains 541 titles, including 318 pertaining to astronomy, 35 to mathematics, 42 to economics, and 146 on miscellaneous

[3] R. C. Archibald. *Simon Newcomb: Bibliography of his life and Work.* Mem. Nat. Acad. Sci., xvii, First Memoir, Pt. II. 1924.

subjects that comprise even fiction! Attention must here be confined to his greatest project, the construction of new theories and tables for the motions of all the principal bodies of the solar system; this undertaking was one which he had long cherished, and upon assuming charge of the Nautical Almanac was enabled to put into execution.

A reconstruction of the lunar and planetary theories and tables was then badly needed, because the precision of astronomical observations had come to exceed the accuracy of the existing mathematical theories of the celestial motions. The computed motions did not represent the actual motions exactly, and the deviation of prediction from observation was constantly increasing. It is true that the discordance between theory and observation was not large enough to be of practical importance in the applications of astronomy; but if the celestial motions are produced solely by gravitational forces that act in conformity with Newton's Law, then a mathematical theory of the motions developed from this hypothesis should represent the observations exactly, over any period of time, and it is of the utmost importance to determine whether any observed discrepancies are due to some inadequacy of that hypothesis, or merely to imperfections of the mathematical theory.

If the solar system were composed of only the sun and a single planet, then the orbit of that planet would be an exact ellipse that would never change its form, size, or position. Actually, however, each of the planets and satellites moves in an exceedingly irregular and ever-changing path, because of the disturbances produced by the attractions of all the other bodies in the system. None of the departures from regular elliptic motion is very great; but the longer and the more accurately the motions are observed, the more complicated they are found to be. Now, there long had been no question, of course, that these irregular motions of the planets around the sun, and those of the satellites around the planets, are at least *very nearly* in accordance with Newton's law of gravitation; but the important question is whether the mutual gravitational attractions given by Newton's Law *completely* explain *all* the manifold irregularities in the actual motions that can be detected by observation.

To answer this question, long continued series of observations of the utmost attainable accuracy are first necessary, to determine with as much precision as possible how each body *does* move; and next, it is necessary to make a theoretical calculation of how each *would* move under only the Newtonian gravitational attractions of all the others, to the same degree of accuracy as the available observations.

Serious difficulties are encountered in both of these steps; and it is not easy to determine with certainty the significance of differences between theory and observation.

In the first place, accurate observations are difficult to obtain with even the finest instruments—untiring industry and great skill are required. Some allowance must always be made for inevitable errors of observation; and to combine observations made at different times and places, by different observers with different instruments, into a homogeneous whole for comparison with theory, is a task that calls for rare ability.

In the second place, the mathematical theories of the celestial motions are of a complexity almost beyond conception: It is well known that the general solution of the problem of even as many as three bodies moving under their mutual gravitational attractions cannot be obtained in any usable form. In the case of the planetary system, the very special circumstance that one of the bodies—the sun—dominates the entire system, permits an approximate solution of any required degree of accuracy to be obtained, valid over a more or less limited interval of time and in a form suitable for numerical calculation, but only at the cost of tremendous labor when the approximation is to be pushed to the accuracy of modern astronomical observations. Single formulae that fill dozens of printed quarto pages, and require months or even years to derive, are not unusual; the final equations that represent the motion of the moon contain over 1400 terms, and to obtain them is almost the work of a lifetime.

Only three times in the entire history of astronomy has anyone had the courage to undertake the systematic construction of complete theories for all the principal bodies of the solar system: The first attempt was by Laplace; his results are contained in the immortal *Mécanique céleste,* and upon them were founded the tables by Lindenau and Bouvard which remained in use for over 50 years. Laplace, however, developed the equations to only a low order of approximation; they were sufficient at that time, and demonstrated the agreement of the celestial motions with Newton's Law to a first approximation, but during the first half of the nineteenth century the development of precision astronomy under the leadership of Bessel, and the accumulation of further observations, led to a need for more accurate theories. The task was undertaken by Leverrier, one of those who had calculated the position of the planet Neptune prior to its telescopic discovery. During the 22 years from 1855 to his death in 1877, Leverrier succeeded in publishing new theories for all the

major planets; his work marked an epoch in gravitational astronomy, and resulted in greatly improved planetary tables, but it still left much to be desired, and deviations of the planets from their tabular positions soon began to appear.

Newcomb therefore set himself, at the age of 42, the task of again developing improved theories of the celestial motions, free from the defects of the previous investigations. The existing tables of the sun, moon, and planets, the catalogues of star positions, and the values of the fundamental astronomical constants that must be determined from observation, were then in a chaotic state; uniformity, and even consistency, were largely lacking. Newcomb planned the construction of theories and tables for all the major planets, the moon, and the other satellites, with an accuracy comparable to that of modern observations, and based on uniform and consistent values of the fundamental constants that themselves should be accurately determined from all existing observational data. It is practically impossible to effect any adequate conception of the appalling magnitude of this monumental project; and even an examination of the published results gives no adequate impression of the intricacy and complexity of the work, or of the immense labor involved in the execution of the program of lunar and planetary investigations which Newcomb mapped out. The determination of the fundamental constants involved the discussion of all observations of worth ever made on the positions of the sun, moon, and planets at the 13 leading observatories of the world since 1750; the number of meridian observations of the sun, Mercury, Venus and Mars alone was 62,030, and merely this part of the work was probably of greater magnitude than any single astronomical investigation ever before undertaken by one individual, although the final results are embodied in a modest octavo volume of only 200 pages—one of the classics of astronomy.[4]

For twenty years, driven by untiring energy and singleness of purpose, and sustained by an unusual power of continuous work, Newcomb devoted himself, solely in the interests of astronomical science, to this colossal task. Needless to say, it could not be performed without aid; not only is a corps of computers necessary, but also assistants with technical ability are needed. Newcomb himself emphasizes this; and he gives due credit, in many formal acknowledgments in his papers and on the title pages of his monographs, to his assistants,

[4] Simon Newcomb. *The elements of the four inner planets and the fundamental constants of astronomy.* Supplement, American Ephemeris and Nautical Almanac for 1897. Washington, 1895.

while in his *Reminiscences* he pays high and generous tribute to those who aided him: The most difficult part of the whole program, the theory and tables of the giant planets Jupiter and Saturn, was assigned to George William Hill, whom Newcomb refers to as easily the greatest master of mathematical astronomy during the last quarter of the 19th century, and who labored incessantly for 10 years on the intricate calculations required by reason of the large masses and mutual proximity of these two great planets. Newcomb writes: "And here was perhaps the greatest living master in the highest and most difficult field of astronomy, winning world-wide recognition for his country in the science, and receiving the salary of a department clerk. I never wrestled harder with a superior than I did with Hon. R. W. Thompson, Secretary of the Navy, about 1880, to induce him to raise Mr. Hill's salary from $1200 to $1400." Hill himself took little interest in this matter—"He did not work for pay, but for the love of science. . . . That I could not secure for him at least the highest official consideration is among the regretful memories of my official life." Of Cleveland Keith, Newcomb says: "Without his help, I fear I should never have brought the tables to a conclusion."

The completion of Newcomb's great program was imperiled by his automatic retirement on March 12, 1897, at the age of 62, accompanied, unfortunately, by circumstances that were not to the credit of those responsible for them and which forced him to cease work on the uncompleted project. Eventually, however, the planetary tables were completed and published, and a star catalogue issued, by the Nautical Almanac Office, partly under Newcomb's supervision. His investigations of the motion of the moon had to be left unfinished, but were later completed during the last six years of his life under the patronage of the Carnegie Institution; the manuscript was finished less than a month before he died. For several months before his death on July 11, 1909, at the age of 74, Newcomb was aware that his days were numbered, and he devoted all his energy, often while in great suffering, to the completion of the lunar work. No lunar tables were constructed, however; and little was ever accomplished with the other satellites in the solar system. The huge task of discussing the comparison of his planetary tables with observation, and all the problems arising therefrom, were left untouched. An enormous mass of material that had been gathered for future work was left, and has remained unused. A great volume of essentially completed work was never published—in particular, a complete exposition

of the investigations and theories on which the planetary tables were based has not appeared. Newcomb wrote in the preface to the tables: "The question to what extent these and other researches shall be completed and published is one the decision of which must be left to others." After a lapse of nearly 40 years, it is only too painfully evident what that decision was.

During the 15 years from 1882 to 1897, eight and a half quarto volumes of the *Astronomical Papers of the American Ephemeris*, a series established by Newcomb expressly for the publication of results connected with his program, were issued under his supervision; during the next 15 years, following his retirement, nothing further was issued, until in 1912 his last memoir on the motion of the moon was posthumously published; in the 23 years since then, two brief monographs and a star catalogue are all that have been added to this series. Except for three brief papers by various authors, the first eight and one-half volumes are made up of twenty-five great monographs by Newcomb himself, three extensive memoirs by Hill, and the theory and tables of Jupiter and Saturn, also by Hill. It is evident that, despite the invaluable assistance rendered by others, the credit for the work that was accomplished belongs to Newcomb; it was due to his ability and vigor in planning the investigations, developing methods and procedures, supervising and checking, and pushing the program ahead, that it was carried as far as it was.

The volumes of the *Astronomical Papers* that contain the results are among the most priceless treasures of astronomical literature; they are now in use in the preparation of the annual emphemerides issued by the principal countries of the world. In his prefaces to the volumes of tables, however, Newcomb writes regretfully: "On surveying the completed work the author is painfully conscious that in several points it fails to reach the standard he had set for it." He enumerates the principal causes of the defects, and calls attention to the fact that a future generation must reconstruct the work.

Newcomb had a facile pen; he wrote clearly, in excellent English; and not the least of his services to astronomy were his many superb popular books and articles. His commanding position in astronomical science was universally recognized, and he was the recipient of a long list of honors, including degrees from 17 universities, and numerous medals and prizes from learned bodies. He was somewhat reserved and unapproachable, and inclined to be gruff, which sometimes led to an erroneous impression of him on the part of those who had not

come to know him; but his personal characteristics, as well as his scientific achievements, won many high tributes at the time of his death.[5]

CHEMISTRY.—*A pH conversion chart.*[1] W. H. Goss, Washington, D. C. (Communicated by F. G. Brickwedde.)

A conveniently arranged chart or graph is useful to biologists and chemists in saving much time when converting emf values to pH readings in measurements on culture media and other solutions with hydrogen, glass, or quinhydrone electrodes and 0.1N, N or 4.1N (saturated) KCl-HgCl reference standards. The stoichiometric and mathematical equations correlating pH and emf values are rather complicated with certain types of electrodes and with special reactions involving, for example, oxidation-reduction. Several constants and variables may be involved in some cases, which must be placed in the equations correctly both as to sign and magnitude. The temperature-emf coefficient of each electrode must be applied. Frequently there is temporary instrumental or electrode hysteresis arising, for example, from electric leaks through moisture on the surface of the potentiometer or leads, or from irregular changes in temperature and activity of reference standards. Recognition and interpretation of these errors require detailed theoretical background and extensive experience beyond the scope of this paper. Such errors obviously cannot be corrected by a single graph or any other simple method. The mathematical expressions correlating emf and pH involve exponential functions which can be solved by use of logarithms or a slide rule. As many scientists in biology and chemistry and factory workers find such calculations foreign to their daily experience, it is believed that a chart will be helpful in work with some of the more commonly used electrode systems when free from the above mentioned errors.

Fig. 1 gives the variation in emf and pH values with temperature for several of these electrode systems. When made about 18 inches wide and 14 inches high the pH values from 0 to 14 can be read to 0.01 with a maximum error of ± 0.02 between 15° and 30°C. An $8'' \times 10''$ photograph can be read to 0.02 pH. This covers the ranges of temperature and the precision needed in most routine measure-

[5] See the Memorial Addresses read before the Philosophical Society of Washington. Bull. Phil. Soc. Wash. 15: 133–167. 1910.

[1] Received July 15, 1935.

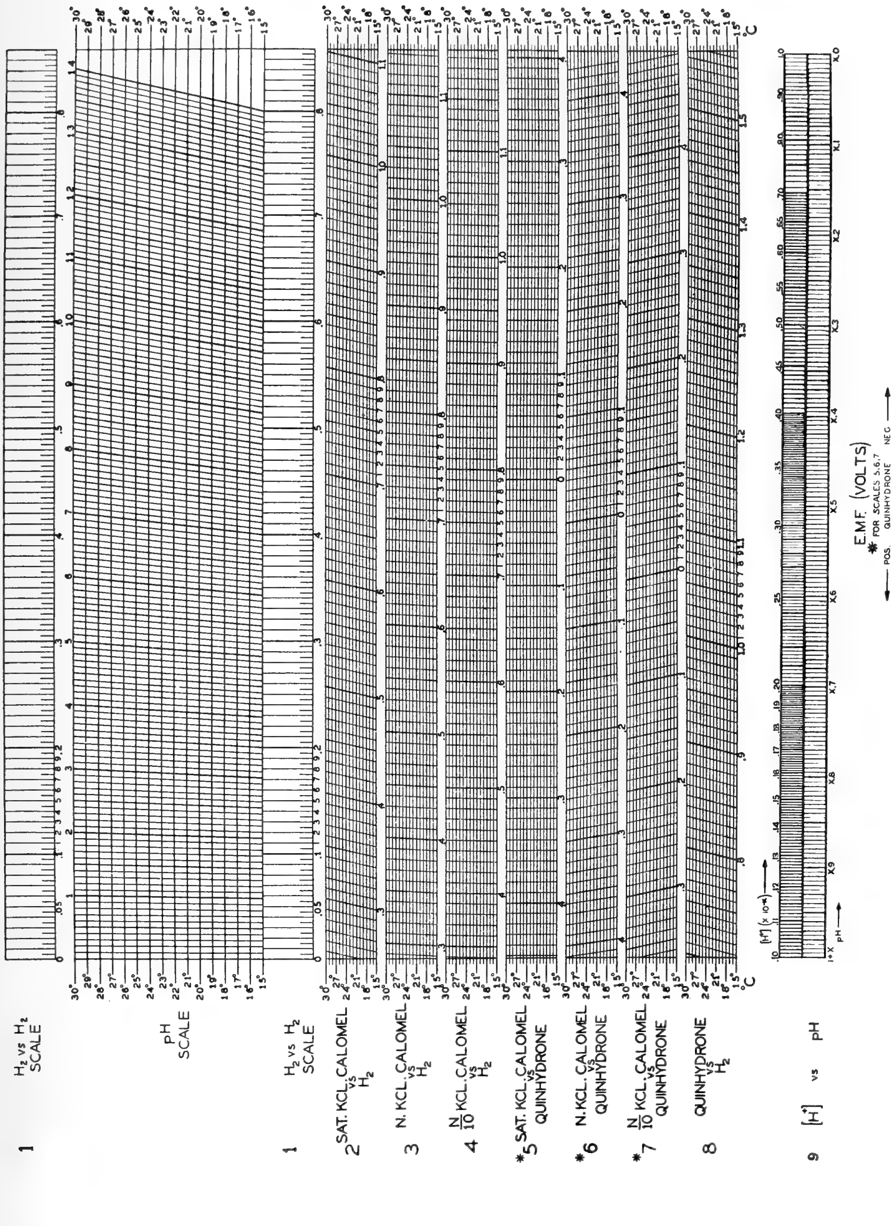


Fig. 1.—A pH conversion chart.

ments. Although the saturated KCl-HgCl reference electrode is perhaps most widely employed, because it has practically no contact potential against most unknowns, the $0.1N$ and N KCl-HgCl standards are frequently used with a saturated KCl solution or agar gel bridge between the calomel and hydrogen electrodes. The graph therefore includes all these systems with no corrections necessary for contact potentials.

The entire chart is made up of ten small horizontal graphs with their designations at the left side. The top and third scales numbered 1 are merely duplicates of the fundamental emf scale. They permit the accurate placing of a straight edge vertically at the same voltage on both to get the reading on the pH scale (second) corresponding to this emf or to any other emf in the lower graphs.

The lower scales, No. 2 to 8 inclusive, give the total emf readings of the indicated electrode pairs corresponding to pH values which can be read directly on the pH scale. The left-hand upper or reference electrode is *positive* (+) to the lower or hydrogen ion electrode and the emf readings in the graphs are therefore *positive* in all cases except in graphs 5, 6 and 7 where the emf to the left of 0 (zero) are *negative* (−) because the quinhydrone electrode is the positive one. (See note at the bottom of the graph.)

The chart is first placed on a small drawing board or table with a straight top edge, preferably under glass, cellophane or celluloid sheets when cleanliness is desired. By use of an accurate T-square with transparent straight edges both ends of No. 1 scale are brought into positions perpendicular to the top edge of the board and the chart is then fastened down with thumb tacks. When the T-square is moved along the top edge of the board to any intermediate position such as at 0.5 volt on the No. 1 scale the pH corresponding thereto and to any emf on the lower graphs at the desired temperature can be easily read.

The second or pH scale gives the pH readings from 0 to 14 corresponding to the emf between a hydrogen (or glass or quinhydrone) electrode in the unknown solution and a duplicate electrode in a standard solution having unit hydrogen ion concentration or activity when at the temperature of the unknown. The contact potentials are assumed to be entirely eliminated. This enlarged pH scale is therefore especially useful in obtaining the pH of the unknown as follows: The standard emf (positive or negative) of the reference electrode *toward* any hydrogen ion electrode (Pt, glass, quinhydrone, antimony, etc.) in a N H^+ solution is algebraically subtracted from the total

emf (positive or negative) given by the unknown solution when measured with the same reference and hydrogen ion electrodes; the difference is an emf found on the No. 1 scale or its extension (to e.g. pH of -1 or 15). The vertical straight edge is run through this point and cuts the horizontal line in the pH scale corresponding to the temperature of the unknown solution at a point which is the pH of the unknown. For example if a saturated calomel reference electrode is $+0.245$ volt toward a Pt-H_2 electrode in N H^+ solution and $+0.745$ volt toward the Pt-H_2 electrode in an unknown solution, the difference is 0.500 volt. If the saturated calomel electrode is -0.453 volt toward a quinhydrone electrode in N H^+ solution and $+0.047$ toward the quinhydrone electrode in an unknown solution, the difference is $+0.047-(-0.453)=+0.500$ volt. Such a difference of $+0.500$ volt on the No. 1 scale corresponds to pH 8.66 if the temperature of the unknown is 18°C. and 8.32 if it is 30°C.

The slopes of the emf lines in graphs Nos. 2, 3, 4, correspond to the temperature coefficients of the 4.1N (saturated), 1N, and 0.1N KCl-HgCl electrodes, -0.00076, -0.00025, and -0.00008 volts per degree, respectively, referred to the hydrogen electrode having zero temperature coefficient. In graph No. 8 the slope of the emf lines represents the temperature coefficient of the quinhydrone electrode, -0.00074 volts per degree, and in graphs Nos. 5, 6, 7 the slopes represent the difference between the temperature coefficient of the quinhydrone electrode and that of the particular KCl-HgCl electrode used. Since the temperature coefficients of the saturated KCl-HgCl and the quinhydrone electrodes are almost equal, -0.00076 and -0.00074 respectively, a cell composed of these has a very small temperature coefficient as shown by the nearly vertical emf lines in graph No. 5.

Graphs Nos. 2 to 8 are used as follows: The reference and hydrogen ion electrodes are assumed to be at the same temperature. Suppose that a total emf of 0.300 volt is measured at 18°C. in the electrode system used in graph No. 2. The straight edge is run from the point of intersection of the 18°C. and 0.3 volt coordinates of graph No. 2 vertically through the pH scale, note being taken that the straight edge gives the same reading on the two No. 1 graphs. The straight edge intersects the 18° line of the pH scale at pH 0.84; if the temperatures of both electrodes are at 30° the pH reading for 0.3 volt is 0.96. Likewise a total emf of 0.6 volt at 18° and 30°C. corresponds to pH 6.04 and 5.95 respectively; and 1.0 volt at 18° and 30°C. gives pH values 12.97 and 12.61.

It will be noted that in some of the different electrode systems Nos. 2 to 8 the pH increase with rise in temperature from 15° to 30°C. may be positive at one end of the pH scale, zero near the center, and negative at the other end. In other words we should be able to calculate for each electrode system the pH value at which the dE/dT slope for the total emf of two electrodes with different temperature coefficients is equal to the slope $dE/dt = -0.000198$ pH for the absolute pH scale. This pH reading remains the same whether both electrodes are at 15° or 30°C. This condition is satisfied when the single electrode potentials E_1 and E_2 for graphs Nos. 2 to 8 give

$$dE_1/dT - dE_2/dT = dE_H/dT = -0.000198 \text{ pH}$$

or

$$\text{pH} = (dE_1/dT - dE_2/dT)/(-0.000198) \quad \text{or} \quad d\text{pH}/dT = 0.0$$

By use of the temperature coefficients chosen above for various electrodes and the above equation it is calculated that for graphs Nos. 2 to 8 the pH values are 3.84, 1.26, 0.40, 0.1, −2.98, −3.33, and 3.74 respectively, at which the pH readings cannot change with equal rise in temperature of both electrodes. To the left of these pH values increase in temperature causes rise in the pH reading for the same emf and the reverse to the right. These pH points for graphs 6 and 7, namely pH −2.98 and −3.33 respectively, correspond to roughly 1000 *N* hydrogen ion concentrations which are beyond practical realization. For graphs 6 and 7, then, the pH always decreases for the same emf with rise in temperature.

It should be noted that in graphs Nos. 2 to 8 the slopes correspond to the difference between the temperature coefficients of the reference and hydrogen ion electrodes used. These are generally kept at the same, preferably constant, temperature such as 25°C., but even if they are at different temperatures the correct pH value can be read from graphs Nos. 2, 3, 4 and 8 by placing the vertical straight edge at the intersection of the observed emf and the horizontal ordinate for the temperature of the reference electrode used and reading off the pH scale at the intersection of the vertical straight edge with the horizontal ordinate for the temperature of the hydrogen ion electrode.

When the two electrodes are at different temperatures and neither has a zero temperature coefficient, as is the case when quinhydrone is used with a calomel electrode in graphs Nos. 5, 6 and 7, a correction for any difference in their temperatures must be applied to the emf reading before using the chart. The correction to be added to the emf reading is the *algebraic* change in the normal emf of the reference

calomel electrode when brought to the temperature of the quinhydrone electrode, and is easily applied as follows: The magnitude of the correction is the temperature coefficient of the calomel electrode multiplied by the difference between its temperature and that of the quinhydrone electrode. If the calomel electrode is at a higher temperature, this correction should be subtracted from the emf reading measured, before consulting the graph, because the calomel electrode temperature coefficients have negative values. If the calomel electrode temperature is lower than that of the quinhydrone electrode, the correction should be added to the reading. As an example assume that a quinhydrone electrode is at 28° and a $0.1N$ calomel electrode is at 18°, and that the emf reading of this cell is -0.136 volts. The temperature coefficient of the $0.1N$ calomel electrode is -0.00008 volts/degree. Then $(-0.00008)(10) = -0.0008$ volts or practically -0.001 volt. Then $-0.136+(-0.001) = -0.137$ volts for use on the chart. The corresponding pH reading on the 28° line of the pH scale and scale No. 7 is 3.74.

The glass electrode is used with so many combinations of internal and external calomel, AgCl-HCl and quinhydrone reference electrodes that the only general rule is to make all corrections for the reference standards (e.g. $0.1N$ HCl-HgCl, $0.1N$ HCl-AgCl, or $0.1N$ HCl-quinhydrone or Thompson's[2] metal coating) necessary to get the emf between the unknown solution on one side of the glass membrane and the pH standard ($H^+ = 1$ or $0.1N$ HCl with pH 1.07) on the other side and use this emf with graph No. 1 and the pH scale to get the difference in pH at the temperature of the glass electrode. This general procedure applies to the use of the chart with the antimony or any other hydrogen ion electrode or buffer standard.

The emf of the reference electrodes toward the normal hydrogen ion electrode and the pH values used in making the chart are those common today: namely, $+0.2496$ at 20°C. and $+0.2420$ at 30°C. for the saturated KCl-HgCl-Hg electrode; $+0.2860$ at 20°C. and $+0.2835$ at 30°C. for the N KCl-HgCl-Hg electrode; $+0.3379$ at 20°C. and $+0.3371$ at 30°C. for the $0.1N$ KCl-HgCl-Hg electrode; and $+0.7029$ at 20°C. and $+0.6955$ at 30°C. for the N H^+-quinhydrone electrode.

Graph No. 9 is a log scale added to make easy the calculation of hydrogen ion concentration from the pH reading. It gives only the mantissa (fraction) of the log as the characteristic (integer) is used by inspection as follows. A pH value such as 7.25 is the log (on base

[2] THOMPSON, M. R. Bur. Standards J. Research 9: 852. 1932.

10) of the *dilution* of the hydrogen ions, i.e., of the number of liters containing one gram equivalent H^+. As concentration (C_H) is the inverse of dilution (V_H in liters), for pH 7.25 $C_H = 1/V_H = 1/10^{7.25} = 10^{0.75}/10^8 = 10^{0.75} \times 10^{-8} = 5.63 \times 10^{-8}$. A graph such as No. 9 would ordinarily read from left to right in making the above calculation, familiar to those regularly employing logarithms, but by constructing the linear scale to read from right to left, the above calculation can be eliminated and the C_H corresponding to any pH value, or vice versa, can be read directly as follows: For pH 7.25 read off the fractional pH value 0.25 from right to left to get the corresponding number, 0.563 in this case. The H-ion concentration is this number multiplied by 10 to a minus power equal to the integer or whole number of the pH value, e.g., $C_H = 0.563 \times 10^{-7}$ or 5.63×10^{-8}. A pH value in integers alone (e.g., pH 7.0) gives directly a C_H value equal to 10 to the negative integer power (e.g., 10^{-7}).

A 14×18 inch enlargement of the pH conversion chart described can be used with a maximum error of ± 0.02 pH unit. It should, therefore, be a valuable aid to biologists, chemists, and students engaged in pH measurements, both as a tool for conversion of routine emf measurements into pH values and as a guide toward a clear conception of the inter-relationships between the electrode systems commonly used in electrometric pH measurements.

ACKNOWLEDGMENT

The writer is indebted to Dr. S. F. Acree of the National Bureau of Standards for suggesting the preparation of such a general purpose pH chart, and to Mr. G. H. Lovins for aid in its design and construction.

PALEONTOLOGY.—*Nomenclatorial notes on fossil and recent Bryozoa.*[1] R. S. BASSLER, U. S. National Museum.

Taxonomic studies of the Bryozoa have interested the writer to such an extent that he recently published a bibliographic index of fossil and recent genera, giving the classification, genotypes, principal citations and other information useful to the specialist on this group.[2] Further researches have shown the necessity for additional changes in nomenclature which are recorded in the present paper.

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received January 17, 1936.

[2] Part 67 of the *Fossilium Catalogus, Bryozoa Generum et Genotyporum Index et Bibliographia.* pp. 1–229, 1935.

Order TREPOSTOMATA Ulrich

Family BATOSTOMELLIDAE Ulrich, 1890

Stenoporella, n. gen.

Like *Stenopora* Lonsdale, 1844, save that instead of diaphragms numerous spines project from the walls into the zooecial cavity, and the beaded structure of the walls is nearly obsolete. *Stenophragma* Munro, 1912, has semidiaphragms projecting from one side of the wall only and has regularly beaded wall structure.

Genotype.—*S. romingeri* n. sp. Mississippian of Arkansas.

Stenoporella romingeri, n. sp. Figs. 1–3

Zoarium an explanate mass about 100 mm in diameter and 25 mm at the thickest portion, consisting of several superposed layers of zooecia, with surface smooth and clusters inconspicuous, the zooecia being nearly uniform in size. Zooecia angular, 8 in 2 mm, thick walled, with mesopores practically wanting. Large acanthopores of the type found in *Stenopora* occupy only the junction angles and average 2 to each zooecium. Diaphragms wanting, their place being taken apparently by semidiaphragms, which in this case appear as spines projecting into the zooecial cavity. These spines resemble similar projections in such genera as *Chaetetes* and *Favosites*, but the presence of *Stenopora*-like acanthopores and wall structure seems to justify the reference of the genus to the Bryozoa.

Occurrence.—Found by Dr. Carl Rominger at Cave Creek, Arkansas, in strata said to be of Chester age.

Holotype.—No. 53833, U. S. National Museum.

Order CYCLOSTOMATA Busk

Family CERAMOPORIDAE Ulrich, 1882

Haplotrypa, n. gen.

This new genus is proposed for various parasitic or discoidal species which have the ceramoporoid wall structure, namely of irregularly laminated tissue, but entirely lack the lunarium characteristic of most other genera of the Ceramoporidae. The apertures are direct, and externally bear a resemblance to the trepostomatous genus *Monotrypa* Nicholson, 1879. *Spatiopora* Ulrich, 1882, consisting of thin parasitic expansions with oblique cells and blunt acanthopores, is a related genus.

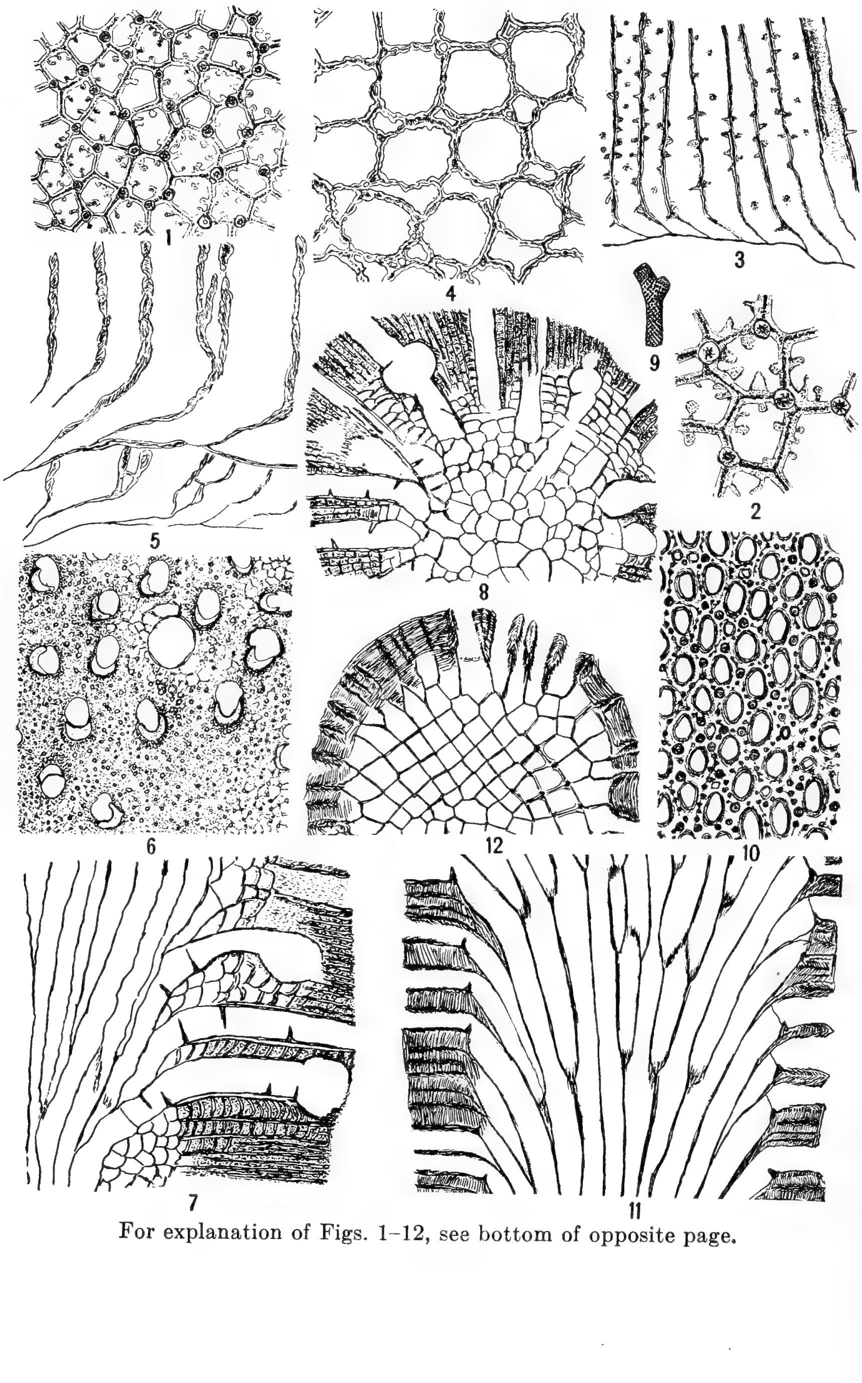
Genotype.—*Haplotrypa typica,* n. sp. Range, Ordovician to Devonian.

Haplotrypa typica, n. sp. Figs. 4, 5

Zoarium a lamellate expansion of superposed layers several centimeters wide and 4 or more mm in thickness. Surface smooth with inconspicuous maculae of larger zooecia, of which there are 3 in 2 mm while 4 of the ordinary ones occur in the same space. Zooecia angular, thin walled, sometimes in contact but often separated by narrow interspaces. In thin sections the laminated, ceramoporoid structure with apparent perforations in the walls is quite evident. Diaphragms are practically absent in both sets of tubes.

Occurrence.—Niagaran group (Osgood), Osgood, Indiana.

Holotype.—No. 92132, U. S. National Museum.



For explanation of Figs. 1–12, see bottom of opposite page.

Order CRYPTOSTOMATA Vine

Family RHABDOMESONTIDAE Vine, 1883

Rhomboporella, n. gen.

Solid, ramose Rhabdomesontidae with the zooecial tubes in the axial region regularly rhombic or quadrate in cross section. Superior hemiseptum and two sets of acanthopores, a large set at the end of the zooecia and a small one entirely surrounding them, well developed.

Genotype.—Rhomboporella typica, n. sp. Carboniferous of Bolivia.

The discovery of this type of structure in the Cryptostomata illustrates an interesting case of parallel development in two different orders of the Bryozoa, as a similar occurrence of rhombic or quadrate zooecia in transverse section is found in the Silurian genus *Rhombotrypa* Ulrich and Bassler 1904, and the Middle Carboniferous *Rhombotrypella* Nikiforova, 1933, belonging to different families of the order Trepostomata. End views of the axial part of the branches in these three genera are so similar as to lead to confusion, but the cryptostomatous characters of the present form are so evident that there can be no thought of close alliance. In each case the similarity is caused by the fact that the zooecia of the immature zone simultaneously at definite intervals develop new tubes and undergo a change in orientation of their sides. This process has been explained in detail by the authors of *Rhombotrypa,*[3] and it will suffice to say here that the rhombic or quadrate cross section is maintained by this concurrent development of new tubes.

Rhomboporella typica, n. sp. Figs. 9–12

Zoarium, a cylindrical, solid, smooth branch, 3 mm in diameter, dividing at intervals. Surface without distinct maculae but with areas of slightly larger zooecia having thicker walls. Zooecia elongate, polygonal, with walls thin to thick according to age, bearing two sets of acanthopores, one of distinctly larger size at the ends of the orifices, and the other of smaller granules ornamenting each wall. Zooecia in irregular quincunx, 6 to 7 in 2 mm measuring along the longer diameter.

Tangential sections reveal the thickened walls, the large and small sets of acanthopores and the few intervening mesopore-like areas. The vertical

[3] Smithsonian Miscellaneous Collections **47**: 44. 1904.

Figs. 1–3.—*Stenoporella romingeri* n. sp. 1, A tangential section through the mature region, ×18, showing the large acanthopores and the semidiaphragms in the form of blunt spines. 2, portion of the same, ×21. 3, vertical section, ×18, exhibiting the aspect of the semidiaphragms in this direction. Chester at Cave Creek, Arkansas.

Figs. 4, 5.—*Haplotrypa typica* n. sp. Tangential and vertical thin sections, ×18, illustrating the ceramoporoid wall structure and the absence of lunaria. Niagaran group (Osgood), Osgood, Indiana.

Figs. 6–8.—*Cliotrypa ramosa* Ulrich and Bassler, n. sp. 6, Tangential section, ×18, near the surface showing the normal zooecia and one of the ovicell-like forms, as well as the granose interspaces. 7, vertical section, ×18, of half of a branch with the ovicell-like expansions and the hemiphragms developed. 8, transverse thin section, ×18. The thin walled immature region and the mature zone with hemiphragms and expanded zooecia, are evident. Mississippian (New Providence shale), King's Mountain, Kentucky.

Figs. 9–12.—*Rhomboporella typica* n. sp. 9, zoarium, natural size. 10, tangential thin section, ×18, through the mature zone. 11, vertical section illustrating the origin of new tubes at regular intervals, and the superior hemiseptum. 12, transverse thin section, ×18, showing the rhombic form of the immature zooecia. Carboniferous of Chulpapampa, Bolivia.

section is with one exception that of a typical member of the Rhabdomesontidae with the superior hemiseptum well developed. The exception, as explained in the generic remarks, is the development of a rather wide immature or axial zone in which the zooecia originate new tubes simultaneously at regular intervals. In vertical fractures of a branch this is shown by alternating smooth and uneven spaces which when cut by the thin section give the aspect exhibited in Fig. 11. Transverse sections are unusually interesting as it is here that the quadrate or rhombic form of the immature zooecia is best exhibited. The end of a branch moistened and viewed under a hand lens shows this character equally well, and gives a ready clue to the species. The large acanthopores originate in the axial region for they are distinctly visible in transverse thin sections.

Occurrence.—Carboniferous of Chulpapampa, Bolivia.

Holotype.— No. 68813, U. S. National Museum.

Family Fistuliporidae Ulrich, 1882

Cliotrypa Ulrich and Bassler, n. gen.

Fistuliporidae like *Fistulocladia* Bassler, 1927, that is, narrow, solid, cylindrical, smooth branches with ovicell-like inflations in the tubes which develop in addition well defined semidiaphragms projecting into the zooecial cavity in the mature region.

This genus originally distinguished and named by Dr. Ulrich and the writer in 1897 when specimens were distributed to various students, was defined by the junior author in the *Paleontology of Timor* **16:** 49, 1929, but remained invalid because the genotype had not been figured. This is herewith corrected with the following description and figures.

Genotype.—*Cliotrypa ramosa* n. sp. Range, Mississippian and Permian.

Cliotrypa ramosa Ulrich and Bassler, n. sp. Figs. 6–8

Zoarium of small, solid, smooth, branching cylindrical stems, 2.5–4 mm in diameter, bearing oval zooecial apertures with strongly marked lunaria, separated by solid, granose interspaces and exhibiting large solid maculae at intervals of about 4 mm. Measuring lengthwise, 4 zooecia occur in 2 mm. In vertical thin sections, the zooecial tubes are thin walled in the solid axial region becoming thick walled in the mature zone and developing at intervals rather thick incomplete plates from alternate sides of the wall as hemiphragms in place of the ordinary diaphragms, and occasionally expanding into spherical, ovicell-like structures which then contract to normal size, or may appear as swollen prominences at the surface. The subsolid interspaces and the maculae are separated by vesicles and towards the surface are traversed by numerous small tubuli.

Occurrence.—Mississippian (New Providence shale), King's Mountain, Kentucky.

Holotype.—No. 92133, U. S. National Museum.

Order CHEILOSTOMATA Busk

The following changes in family, generic, and specific names are suggested in this order.

Family Urceoliporidae, new name

Proposed in place of Euthyridae Levinsen, 1909, invalid name, since *Euthyris* Hincks, 1882, is preoccupied by the fossil brachiopod genus *Euthyris* Quenstedt, 1869.

Genus **Euthyrisella,** n. gen.

Named in place of *Euthyris* Hincks, 1882, preoccupied by *Euthyris* Quenstedt, 1869.

Genotype.—Euthyris obtecta Hincks, 1882. Recent of North Australia.

Family Cheiloporinidae, new name

The genus *Hippopodina* Levinsen, 1909, was described as possessing an endotoichal ovicell and the family Hippopodinidae was founded by him in 1909, based upon this character. However, the ovicell in the genotype, *Hippopodina feegensis* Busk, 1884, is hyperstomial, and the genera with endozooecial ovicell must be classified otherwise. The new family Cheiloporinidae is, therefore, proposed, based upon *Cheiloporina* Canu and Bassler, 1923, a genus with numerous species, ranging from the Eocene to the Recent. The family Hippopodinidae may be retained for the single type genus or future researches may show it to be related to the Schizoporellidae.

Adeona joloensis, new name

Proposed for *Adeona porosa* Canu and Bassler, 1929, from Jolo, Philippines, preoccupied by *Adeona porosa* Canu and Bassler, 1923, from the Miocene of Santo Domingo.

Escharoides erectoides, new name

Proposed for *Peristomella erecta* Canu and Bassler, 1920, from the Tertiary of South Australia, preoccupied by *Peristomella erecta* Canu and Bassler, 1920, from the Vicksburgian of Alabama, both species now being referred to *Escharoides.*

Callopora horniana, new name

Proposed to replace *Callopora crassospina* Canu and Bassler, 1923, from the Pleistocene of California, preoccupied by *Callopora crassospina* Canu and Bassler, 1920, from the Eocene of North Carolina.

Cellaria elongatoides, new name

Proposed in place of *Cellaria elongata* Canu and Bassler, 1928, from Morocco, preoccupied by *Cellaria elongata* Canu, 1908, from the Patagonian of Argentina.

Floridina voigti, new name

Name proposed for *Floridina bifoliata* Voigt, 1930, from the Danian drift of Anhalt, Germany, preoccupied by *Floridina bifoliata* Canu and Bassler, 1920, a Tertiary species from Mississippi.

Dacryonella minuta, new name

Proposed for *Dacryonella minor* Canu and Bassler, 1920, from the Jacksonian of Florida, preoccupied by *Dacryonella* (*Membranipora*) *minor* Hincks, 1885, a recent species.

Gemelliporina, new genus

Gemellipora Smitt, 1872, by the rules of nomenclature, is a synonym of *Pasythea* Lamouroux, 1871, so that the second group of species typified by *Gemellipora glabra* Smitt, 1872, retained under this name by Canu and Bassler, must be classified elsewhere. The new name *Gemelliporina* is, there-

fore, here proposed for species with keyhole-like aperture, hyperstomial ovicell and tremocyst frontal, with *Gemellipora glabra* Smitt, 1872, a common species of the Gulf of Mexico, as the genotype.

Figularia duvergieri, new name

Proposed for *Figularia carinata* Duvergier, 1924, from the Helvetian of Salles, France, preoccupied by *Figularia* (*Figulina*) *carinata* Waters, 1923, a recent species from the East Indies.

To the *Fossilium Catalogus* the following generic citations should be added:

Spirillopora Gürich, 1896. Lower Devonian

Gürich, Verh. d. Russ.-Kais. Mineral, Gesell. zu St. Petersburg, (2) XXXII, p. 213, 1896.

Genotype.—*S. anguillula* Gürich, 1896, idem, p. 213, pl. X, fig. 17. Poland. Unrecognizable. Figure shows only a twisted stem with cells in spiral rows.

Vetofistula Etheridge, Jr., 1917. Devonian

Etheridge, Jr., Geol. Surv. Queensland, Pub. No. 26, p. 17, 1917.

Genotype.—*V. mirabilis* Etheridge, Jr., 1917. Not recognizable.

Zeapora Penecke, 1893. Devonian

Penecke, Jahrb. d. kk. geol. Reichsanst. XLIII, p. 610, 1893.

Genotype.—*Z. gracilis* Penecke, 1893. Alps. Unrecognizable. A trepostome but illustrated by only a poor section.

PALEONTOLOGY.—*A new* Allagecrinus *from Oklahoma.*[1] EDWIN KIRK, U. S. Geological Survey.

The U. S. National Museum has recently acquired a number of Pennsylvanian crinoids from Mr. H. L. Strimple of Bartlesville, Oklahoma. Some of them are of considerable biologic and stratigraphic interest, and Mr. Strimple deserves much credit for discovering and calling attention to this material from a hitherto barren field. The most interesting crinoids collected are a suite of *Allagecrinus* preserving the arms. *Allagecrinus* and allied genera have been known for a long time from many parts of the world, and several hundred specimens have been collected. Up to the present, however, none has been found with the arms attached. The species itself proves to be new and is here described as *Allagecrinus strimplei.* Altogether 10 dorsal cups and 18 complete crowns, as well as several sets of dissociated arms, have been available for study.

[1] Published by permission of the Director, U. S. Geological Survey. Received January 29, 1936.

Allagecrinus strimplei, n. sp.

The species is comparable in size with the larger known species of *Allagecrinus* from the Pennsylvanian and Permian. The largest dorsal cup has a diameter of approximately 5 mm. The smallest individual is about one-half as large. The largest complete crown has a height of 12 mm. The other

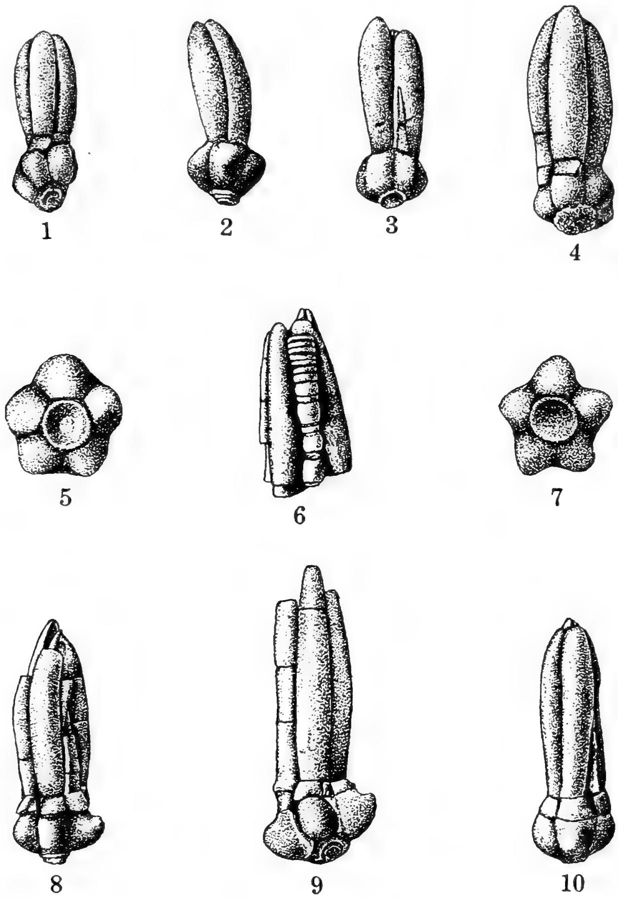


Fig. 1.—*Allagecrinus strimplei,* n. sp. Young individual in three-arm stage. Fig. 2.—Four-arm stage. Fig. 3.—Three-arm stage with incipient fourth arm appearing. Fig. 4.—Four-arm stage, primary arm in center and secondary arm to left. Figs. 5, 7.—Basal views of two dorsal cups showing variation in lobation. Fig. 6.—Proximal portion of column lying on a set of arms. Fig. 8.—Five-arm stage; primary arm in center; secondary arms to right and left. Fig. 9.—Largest complete crown; primary arms in center and to right; secondary arm to left. All figures are ×3. They have been drawn in pen and ink from photographs and are somewhat diagrammatic.

specimens are intermediate in size and yield a fair series of growth stages that are especially interesting as regards the development of the arms.

The dorsal cup is depressed bowl shaped, with a diameter approximately twice the height. The radials are tumid, giving the dorsal cup a distinctly pentalobate to substellate outline as seen from above or below. The basals form a pentagon approximately two-fifths the diameter of the cup. What

appear to be sutures within the basal circlet may be seen at times, but the almost complete coverage of the basals by the proximal columnal makes it impossible to identify and orient the basal elements with certainty. If sutures are present, as seems probable, one would expect three unequal elements. The radials are higher than wide. In very young specimens the radials are moderately convex. With increasing age the radials become more and more tumid. In the largest specimens each radial bears a large protuberance. In most cases the upper surface of this knob is flattened to concave as seen in profile. This is well shown in the drawings. The tumidity of the radials varies in amount and character as between individuals of nearly the same stage of development, and even between different radials of the same specimen. Based on the relative convexity of the radials the series of specimens in hand could readily be separated into two species, the younger specimens in one species and the older in another. The right and left posterior radials are but slightly notched by the first anal plate, so little in fact that it is difficult to identify the posterior interradius except in very well-preserved and carefully cleaned specimens. The anal plate notches more deeply into the right posterior radial than the left. The articulating face of each radial is produced inward as a shelf. On this shelf the position of each arm is marked by a depression bounded on the sides by converging ridges. The shelf supporting the arms is continuous except in the posterior interradius. In the posterior interradius the shelf is interrupted by a parabolic notch which in well-preserved specimens is clearly shown.

In the youngest specimens which have the arms preserved, three large arms are present. Later, additional arms appear. In the oldest specimens preserving the arms, five arms of approximately equal size are found. In the largest dorsal cup the converging ridges on the superior faces of the radials and the articulating facets indicate at least eight arms, with a possibility that a ninth arm is just beginning to appear. If so, this ninth arm would give three arms to one ray, which is the left posterior. The radials bearing two arms each are the left posterior, anterior, and right anterior. Owing to the fact that we do not have a large number of dorsal cups, and that where the arms are preserved they are often partially detached from the radials and shifted from their original positions, it is not possible to determine accurately the orientation of the three original arms.

The arms are variable in structure. The three primary arms seem to agree in being made up of a short first brachial followed by a very long second brachial. Additional brachials are added subsequently. The secondary arms have the short first brachial, but the second brachials are not so disproportionately long, and several shorter brachials make up the length attained by the two brachials of the three primary arms. An average of many measurements of the first brachials gives a length of 0.9 mm. In the primary arms the second brachials have an average length of 6.7 mm. In one ray where several brachials are preserved, presumably a secondary arm, the brachials give the following measurements: 1, 0.9 mm; 2, 1.7 mm; 3, 2.1 mm; 4, 2.6 mm. Another arm of the same type gives the following measurements for the brachials: 1, 0.9 mm; 2, 1.3 mm; 3, 1.6 mm; 4, 1.8 mm; 5, 2 mm. In the secondary arms the greatest variation in length seems to be found in the third brachial, measurements varying from 1.3 mm to 3.4 mm. The mature brachials have an average maximum breadth of 1.4 mm. The backs are strongly convex, and the surface is covered with fine granulations. The secondary arms as they first appear have flat or slightly convex backs, which gradually increase in convexity with age. The union of the first

brachial with the radial is weak, as is also the union between the first and second brachials. As a result the arms are seldom in true alignment and in their original positions.

Fortunately fragments of column have been found in such relationships with the *Allagecrinus* crowns as to leave no doubt as to their belonging together. The column figured lies on a set of arms and is incomplete in its proximal portion. The proximal columnals are thin and become narrower distad. This tapering proximal portion of the column is similar to that commonly found in the Flexibilia. Below the tapering columnals the character of the column changes completely. The columnals are beadlike, and the nodals are relatively large. The general aspect of the column is very like that of one of the young Flexibilia from the Devonian or Mississippian.

There is no described species of *Allagecrinus* with which *A. strimplei* may be confused.

Horizon and locality.—The specimens were collected by Mr. H. L. Strimple in the Dewey limestone (Pennsylvanian) near Dewey, Oklahoma.

Types.—The cotypes are in the Springer collection in the U. S. National Museum, No. S. 4126.

BIOLOGY.—*Food of Arctic birds and mammals collected by the Bartlett Expeditions of 1931, 1932, and 1933.*[1] CLARENCE COTTAM, U. S. Biological Survey. (Communicated by WALDO L. SCHMITT.)

On Captain R. A. Bartlett's three arctic expeditions in the summers of 1931, 1932, and 1933, alimentary material, mostly gullet and stomach or gizzard contents of 115 birds representing 21 species and one additional subspecies, was collected. This material, subsequently submitted to the Biological Survey for analysis, forms the basis for this paper. Fifty-three birds were secured on the first expedition during July and August from northwestern Greenland in the vicinity of Clavering Island, northward to slightly beyond the 74th parallel north latitude and between the 13th and 29th meridians west longitude. The second expedition returned with 20 birds from western and northern Greenland, northward to latitude 76° 33′. These birds, likewise, were taken during the months of July and August. Localities mentioned were Parker Snow Bay, Dalrymple Island, Cape York, Walstenholme, and North Star Bay in latitude 76° 33′. During the 1933 expedition, which extended from July to September, one weasel and five ground squirrels were collected in addition to 42 birds. Collections were made in the area between northern Hudson Bay and western Greenland. Localities recorded included Melville Peninsula; Duckett's Cove, Hudson Strait; Igloolik Island near Fury and Hecla Strait; Cape Frigid, Southhampton Island; and the open seas at latitude 61° north and longitude 64° 20′ west.

[1] Received February 11, 1936.

Even though the number of individuals and species in the collections is not so large as one might wish, they are of more than ordinary importance as they represent a far northern area in which but little critical study of the food habits of birds has previously been made. The majority of these species were poorly represented, or even entirely wanting in the "stomach files" of the Biological Survey.

While the writer examined the majority of the stomachs submitted, generous assistance in this regard was received from A. L. Nelson, Cecil S. Williams, Leon H. Kelso, and F. H. May, all of the staff of the Biological Survey food-habits research laboratories. Specialists who aided by making identifications of questionable material include: Dr. Waldo Schmitt and Clarence Shoemaker, of the U. S. National Museum, on crustaceans; F. M. Uhler, of the Biological Survey, fishes; Wm. B. Marshall, of the U. S. National Museum, mollusks; J. R. Malloch, of the Biological Survey, two-winged flies (Diptera); and Dr. R. V. Chamberlin, of the University of Utah, spiders.

A summary of the food percentages by volume as determined from the analysis of stomachs, gullets, or crops of the birds collected on these expeditions follows:

Gavia stellata (Pontoppidan). Red-throated Loon.

Five adult and two juvenile stomachs of the red-throated loon provide convincing evidence that the birds' piscivorous tendencies dominate. Two adult stomachs were taken from Clavering Island, northeast Greenland, two from Igloolik Island, northwest Greenland, and one from Cape Frigid, Southhampton Island, Northwest Territory. Four of these adult birds had made their entire meals on small coarse fish, largely Gadidae (? *Boreogadus saida*), sculpins (Cottidae), and tomcod (*Microgadus tomcod*), while the other had made 80 percent of its meal on sculpins (Cottidae), tomcod (*Microgadus tomcod*) and sand launce (*Ammodytes* sp.). The remaining 20 percent of the meal of this bird consisted of 54 polychaete (marine) worms, apparently a species of Nereidae.

The food of these five adult birds would be summarized as follows: Cottidae, 34.2 percent; tomcod (*Microgadus tomcod*), 4.8 percent; *Ammodytes* sp., 2 per cent; codfish (Gadidae, part probably *Boreogadus saida*), 30 percent; miscellaneous fish, 25 percent; polychaetes, apparently Nereidae, 4 percent; copepoda and undetermined crustacea (which may have come from the stomach of a party-digested fish), trace.

From the size of the stomachs of the two juvenile birds, taken at Igloolik Island, it would appear that the birds were probably three-fourths grown. It is evident that the food of adults and juveniles varies considerably. Perhaps because the young are less agile and therefore less expert as fishermen, they consume fewer fish. In the two birds examined a greater variety of food was noted than in the adults. It was surprising to find that a moss of the family Hypnaceae made up 43 percent and 33 percent respectively of the two meals. It was noted that all the moss was in the gizzard and from appearance it had

been there for some time. Perhaps in this group of birds the effects of digestive action are less rapid on plant than on animal substances. Feathers are often found in quantity in the stomachs of loons and grebes, yet their function is not definitely known. Some have believed that they serve to protect the stomach walls against the sharp fish bones. It is not known whether the moss in these juvenile birds' stomachs was serving as a source of food, or, similarly, as a protection to the tender, growing gastric organ against the sharp fish-bone fragments.

The stomachs and gullets of both juveniles were well-filled and may be thus summarized: Tomcod (*Microgadus tomcod*), 59.5 percent; sculpin (*Cottidae*), 5 percent; polychaetes, apparently Nereidae, 2 percent; squid (*Loligo* sp.), 0.5 percent; moss (Hypnaceae) plant fiber, 38 percent; gastropods, trace; crustacea, including amphipoda and schizopoda (which may have been taken by the fish), trace.

Fulmarus glacialis glacialis (Linnaeus). Atlantic Fulmar.

Because the Biological Survey has no other record of a stomach examination of the Atlantic fulmar it is to be regretted that only one well-filled stomach of this bird was submitted for examination. It was collected at 61° north latitude and 32°10′ west longitude. This stomach contained the rather indigestible fragments of the lenses of fish eyes from a preceding meal, amounting to 1 percent of the total food content. Fragments of two squid (*Loligo pealei*) made up 11 percent of the food consumed, and finely ground fragments of an unidentifiable mollusk, 1 percent. The remains of 52 marine worms (Nereidae) formed the bulk of the meal, amounting to 86 percent of the total stomach content. Wood fibers and vegetable debris constituted the remaining 1 percent. Many small parasitic gizzard worms (Nematodes) were also found in the stomach. Two bird lice collected from the bird's plumage were identified by Dr. H. E. Ewing of the Bureau of Entomology as *Ancistrona vagelli* Fab.

Branta leucopsis (Bechstein). Barnacle Goose.

Only one stomach of the rare barnacle goose was included, and it was only about one-fourth filled with finely ground vegetable fiber. Of this, 40 percent was sedge (*Scirpus* sp.), 35 percent grass fiber (probably *Poa* sp.,), and the remaining 25 percent was unidentifiable. Sixty-one percent of the total stomach content consisted of fine sand. Løppenthin (6, p. 42) in his studies of Greenland birds states that he found grass, leaves, and stems of serpent-grass (*Polygonum viviparum*) and mountain sorrel (*Oxyria digyna*) in stomachs of this species.

Clangula hyemalis (Linnaeus). Old Squaw.

One stomach of the old squaw, or long-tailed duck, was obtained from the far north (Cape Frigid) and unfortunately it was too nearly empty to shed much light on the normal food preferences. The following items, however, were noted: Fragments of midge (Chironomidae) larvae; soft-bodied crustacea too finely comminuted for identification; sessile barnacles (Balanidae); limpet shells (*Acmaea* sp.); bivalves (pelecypoda) too finely broken to indicate species; seed fragments and plant fiber of sedge, probably *Carex* sp.; moss; and undetermined plant fiber. A fairly large series of stomachs of this attractive bird, examined in the Biological Survey, indicates that it feeds largely on crustaceans and mollusks.

Somateria mollissima borealis (Brehm). Northern Eider.

Information obtained from examination of five well-filled stomachs of the northern eider, collected at Clavering Island, northeast Greenland, on August 6, and compared with two stomachs collected on the New England coast in February and March of earlier years, suggests that this northern duck consumes a higher percentage of fish in summer than it does in winter. Furthermore, these five examinations indicate that this species probably eats more fish than do other eider ducks. Fishes of the family Cottidae (sculpin) were found in each of the five stomachs examined and ranged from 2 percent in one stomach to 79 percent in another, with an average of 26 percent of the total food content for the five stomachs. The number of individual fishes eaten varied from 1 to 25, with two birds each consuming the latter number.

As would be expected, mollusks constituted the largest percentage of the food, averaging 65 percent of the total. In bulk this was nearly equally divided between bivalves and univalves, the former averaging 33.4 percent and the latter 31.6 percent. A species of soft-shelled clam (*Mya* sp.) occurred most frequently and amounted to 16 percent of all food taken. Other bivalves, occurring in about the order of their importance, were the arctic rock-borer (*Saxicava arctica*), the common edible mussel (*Mytilus edulis*), and another mussel (*Crenella* sp.). Of the univalves, the whelks (*Buccinum* sp. and *Tritonofusus* sp.) occurred in each of the five stomachs and averaged 5.6 percent and 3 percent respectively of the total food content. A species of moon shell (*Natica* sp.) occurred in four stomachs and a bubble shell (*Bulla* sp.) occurred in one. Gastropods too thoroughly disintegrated to be accurately named made up 20 percent of the total food consumed.

Soft-bodied crustacea formed 7.2 percent, amphipoda (mainly *Atylus carinatus* and *Corophium* sp.) being most important. Fragments of cumaceans and isopods were recognizable in two of the stomachs.

Fragments of the following minor items made up 0.4 percent of the total food: Protozon (Foraminifera); worms (Annelida); starfish (Asteroidea); and beetles (Coleoptera). Vegetable food, consisting of sedge and moss plant fiber and algae, formed 1.4 percent.

Gravel is found in practically all duck stomachs, and in these five northern eiders, it made up 11.6 percent of the total stomach content. This, however, was not figured in the food percentages. A few feather fragments—most probably from the bird's own plumage—were found in one stomach. Feather fragments are frequently found in the stomachs of many birds, and particularly is this true of most waterfowl.

The five stomachs examined contained an average of more than 12 items per stomach. In contrast to this, the two winter birds collected along the New England coast contained only mollusks. One of these was filled with the common edible mussel (*Mytilus edulis*) and the other, which was nearly empty, contained fragments of the common mud snail (*Nassa obsoleta*).

Falco rusticolus candicans (Gmelin). White Gyrfalcon.

Five stomachs of the white gyrfalcon were obtained during the third expedition on different dates in August and September at various points on the Melville Peninsula. The stomach and small intestines of one bird were entirely empty of food, but contained many tapeworms.

Of the other four birds, one had made its entire meal on 2 collared lemming mice (*Dicrostonyx rubricatus richardsoni*) and another had made 97 per cent of its meal on 3 of these rodents, a horned lark (*Otocoris alpestris*) making up the remaining 3 percent of the food. The Melville Peninsula is

regarded as representing the northern border of the range of this rodent. The third gyrfalcon had in its stomach the remains of one red-backed mouse (*Evotomys* sp.) but, unfortunately, digestion had proceeded too far to permit accurate specific identification. *Evotomys gapperi*, according to Preble (8, pp. 50–51), is the species extending north to the Fort Churchill area. His brother, Alfred E. Preble, according to the report (Preble, 1902, p. 51), collected one specimen 15 miles north of this locality. It is not known what race occurs in the Melville Peninsula area, a region from 600 to 900 miles north of the record cited by Preble, which is the northernmost record in eastern North America. It is not improbable therefore that the specimen obtained from the falcon's stomach, which marks a notable extension of the range of this genus, is a new race or species of *Evotomys*.

The fourth gyrfalcon had made its entire meal of a luckless willow ptarmigan (*Lagopus lagopus albus*). While it is evident from the limited data available that this raptor does not shun bird food, the facts also indicate that rodents likewise are taken in numbers and probably are equally acceptable as an article of diet. Most published comments of the food habits of this bird would lead us to believe that only game and other birds enter into its diet. Bendire (1, p. 282) writes that "The natives assured me that they [the falcons] repair to the rugged mountains . . . to breed, and that they fed their young on the rock ptarmigan, which also seek that region for the same purpose. As a rule, these rocky cliffs are the summer homes of innumerable waterfowl, on whose young, as well as on ptarmigan, they prey to a great extent during the season of reproduction." Hagerup (3, pp. 292–293) writes of ptarmigan serving as the source of food for the bird in southern Greenland. Kumlien (5, p. 84) in his account of arctic American birds states that this falcon subsists wholly on ptarmigans and hares during the winter, and that while on his frequent excursions upon Disko Island he often had opportunity of witnessing the hawk preying upon jaegers, kittiwakes, and other birds. He added that he was surprised that this predator does not possess swifter powers of flight and stated that "their success seems to depend more upon a stubborn perseverance than alacrity of flight." Macmillan (7, p. 409) concludes that it feeds on eider ducks, Mandt's guillemots, ptarmigan, dovekies, and arctic hares. Other writers also mention that birds form its principal source of food. Stomach examination, however, indicates that rodents and other small mammals enter prominently into the species' bill of fare.

Falco peregrinus anatum (Bonaparte). Duck Hawk

Two young birds taken on the Barrow River, Melville Peninsula, August 29, 1933 were available for food habits study. One bird had made its entire meal on a Richardson collared lemming (*Dicrostonyx rubricatus richardsoni*) while the other had its stomach filled with bird bones and feathers, 40 percent of which was from a phalarope, apparently *Phalaropus fulicarius* and 60 percent from a red-backed sandpiper (*Pelidna alpina sakhalina*).

Lagopus rupestris reinhardti (Brehm). Reinhardt's Ptarmigan.

The contents of three stomachs with crops of Reinhardt's ptarmigan, collected August 6, at Clavering Island, were on hand for stomach analysis. All these apparently were fairly well filled, the contents indicating that this subspecies has food habits much in common with other varieties of ptarmigan. They are all highly vegetarian and seem to choose the vegetative

and succulent parts of many herbs and shrubs. It is interesting to note that each ptarmigan collected for this study had taken a trace of insects or spiders, yet of the total food content, animal matter equalled only 0.3 percent, with 2 percent as a maximum for one stomach. This bird had taken three species of flies, dungflies (*Scatophaga furcata*), dance flies (*Rhamphomyia* sp.) and *Spilogona* sp. and one spider (*Dictyna* sp.). One other bird had taken one ant (*Formica* sp.) and one fly (*Spilogona* sp.).

Bulblets of serpent-grass (*Polygonum viviparum*) were the dominant item, averaging 44.8 percent of all food consumed. One crop contained no fewer than 2,300 of these bulblets, which formed 100 percent of the food, while another had consumed more than 1,200, making it 87 percent of the meal. The flowers with mature akenes and leafy fragments of White Mountain avens (*Dryas octopetala*) ranked second in importance, averaging 19.4 percent of the total food of the three birds and amounted to 48 percent of the meal of one. The scales, spikes, and akenes of short-leaved sedge (*Carex misandra*), constituting 18.9 percent of the total average, made this species only slightly less important. One stomach contained about 500 akenes and fragments of probably 20 spikes of this species of sedge, which was 86 percent of that meal. The other contents were: Buds, leaves, and stems of an artic willow (*Salix* sp.), 5.1 percent; seeds of alpine bearberry (*Arctostaphylos alpina*), 3.3 percent; leaves and stems of purple saxifrage (*Antiphylla oppositifolia*, 3.1 percent; seeds and fruiting bodies of sedge (*Carex nardina*), 2.8 percent; fruiting and leafy portions of spiked wood-rush (*Juncoides spicatum*), horsetail (*Equisetum* sp.), sandwort (*Arenaria* sp.), crowfoot (*Ranunculus* sp.), twisted whitlow grass (*Draba incana*), hairy lousewort (*Pedicularis hirsuta*), lousewort (*Pedicularis* sp.), speedwell (*Veronica* sp.), 2.3 percent.

There was an average of 12 species of food items per bird. While 17.7 percent of the total stomach and crop content was gravel, this was not computed as a part of the food contents.

Arenaria interpres interpres (Linnaeus). European Turnstone.

From an examination of three stomachs, collected August 7 at Hudson Land, northeastern Greenland, it would seem that the arctic individuals of the European turnstone are more or less omnivorous in their feeding habits. These three birds contained an average of twelve species of items per stomach with a total of twenty-one. The three stomachs contained 74.67 percent animal tissue and 25.33 percent plant fiber. Gravel (not included in food percentages) amounted to 22 percent of the total stomach contents. Those food items found in excess of 1 percent of the total, were: Crustaceans (mainly amphipods), 23.3 percent; diptera (two-winged flies, mainly craneflies Tipulidae and Anthomyiidae), 20.9 percent; wood and other plant fiber, 13 percent; algae, 12.34 percent; sea-squirt, or ascidian, 9.3 percent; spiders and salt-water mites, 6 percent; brittle-stars (Ophiuroidea), 5 percent; bees and wasps (hymenoptera, mainly Ichneumonidae), 3.67 percent; beetles (coleoptera), 2.67 percent; butterflies (Lepidoptera), 1.7 percent; snails (gastropoda), 1 percent. Fragments of fish and a marine worm made up the remaining 1.12 percent.

Løppenthin (6, p. 55) found midges, snakeflies, the larvae of a cranefly (*Tipula* sp.), larvae of caddice flies (Trichoptera), a few ichneumon flies (Ichneumonidae), a spider, fragments of a phalangid (*Mitopus morio*) which previously had not been recorded so far north in eastern Greenland and gravel in the stomachs of a number of birds examined.

Calidris canutus rufus (Wilson). American Knot.

An examination of the stomach content of four adult and two juvenile American knots collected on the second expedition at Parker Snow Bay, west Greenland, revealed that this bird has a varied diet. The four adults had subsisted largely upon plant fiber and rootlets, which they had finely pulverized. Each bird had made most of its meal on this material. It was somewhat surprising that vegetable substance entered so prominently into the bill-of-fare, forming 93 percent of the adults' and 24 percent of the juveniles' food. Dipterous forms, largely larvae, were the principal animal food of the young birds, while snails (gastropoda) and undetermined fragments of mollusks comprised the chief source of protein food for the adults.

A summary of the food of these birds follows:

Four adults.—Fragments of gastropods and unidentified mollusks, 6.25 percent; midges (Chironomidae) and other flies (Diptera), mostly larvae, 0.75 percent; spider, trace; crustaceans, trace; fish (taken by one bird), trace; bird louse (*Degeeriella* sp.), trace; moss plant fiber, 1.25 percent; Phippsia grass (*Phippsia* sp.), 16.25 percent; undetermined plant fiber and rootlets, 75.50 percent.

Two juveniles.—Fragments of midges (Chironomidae), mostly larvae, 27 percent; salt flies (Ephydridae), 17.50 percent; two-winged flies (Diptera), too broken to permit more specific identification, 11.50 percent; bees and wasps (Hymenoptera), 6 percent; spiders, 2.50 percent; univalves (gastropoda) and undetermined mollusca, 4.50 percent; amphipoda, 4 percent; moss, 1 percent; meadow grass (*Poa* sp.), foxtail grass (*Alopecurus* sp.), cinquefoil (*Potentilla* sp.), and willow (*Salix* sp.), each 0.50 percent; fragment of undetermined grass (Gramineae), 10 percent; sedge (*Carex* sp.), 4 percent; and undetermined plant fiber and rootlets, 10 percent.

K. Henriksen, according to Løppenthin (6, p. 58) found the birds in northeast Greenland feeding on midges and stems of serpent-grass (*Polygonum viviparum*).

Phalaropus fulicarius (Linnaeus). Red Phalarope.

Two red phalaropes were collected by the third expedition on July 20, 1933 at latitude 61° north and longitude 24°20′ west, but unfortunately the stomachs of both birds were only partly filled, although several items of food were noted. The following items in their approximate percentages were recorded for the two separate birds: No. 1. Fragments of lace-winged flies (Chrysopidae, probably *Chrysopa* sp.), two-winged flies (Ephydridae, Chironomidae, Syrphidae, Asilidae, *Megaselida* sp., Dolichopodidae, and undetermined Diptera), squash bugs (Coreidae) and other Hemiptera, sawflies (Tenthredinidae), grasshoppers (Orthoptera) and beetles (Coleoptera), 90 percent; pulp of some seeds, probably sedge (*Carex* sp.), and vegetable debris, 10 percent. No. 2. Fragments of waterboatmen (Corixidae), 25 percent; fragments of midges (Chironomidae) and robber flies (Asilidae), 25 percent; seed pulp and one seed of sedge (*Carex* sp.), 50 percent.

Stercorarius parasiticus (Linnaeus). Parasitic Jaeger.

The stomach of one July specimen, taken in the Greenland Sea, at 73°32′ north latitude and 17°10′ west longitude, contained the remains of five or more tomcod (*Microgadus tomcod*), forming 41 percent of the meal. The remains of many crustacea, mainly amphipods (*Themisto libellula*) made up the remaining 59 percent. It is not known whether this food or the meals of

the two succeeding species were captured direct or resulted from forced regurgitations by other birds.

Løppenthin (6, pp. 84–85) states that in an adult female's stomach a lemming mouse was found. A juvenile bird had 3 small fishes in its gullet, while its stomach contained fragments of fish and a lemming mouse besides pieces of grass, stems, and gravel.

Stercorarius longicaudus Vieillot. Long-tailed Jaeger.

Two specimens of the long-tailed jaeger were collected on the same date and in about the same part of the Greenland Sea as the preceding species. Like the parasitic jaeger, these birds also had their stomachs filled with fish and crustaceans, suggesting that their food habits, when the birds occur in the same general region, are very similar. One stomach contained the remains of ten fish (seven of which were tomcod) besides considerable crustacean material. Fish (tomcod and an undetermined species) formed 29.5 percent of the total, while the following crustaceans made up the remaining 70.5 percent: schizopods (*Thysanoessa inermis*), 37.5 percent; amphipods, including *Themisto libellula*, 17.5 percent and *Gammarus locusta* 2.5 percent; and unidentifiable soft-bodied crustaceans, 13 percent.

Løppenthin (6, p. 93) comments that numerous items are taken as food by these birds. In good lemming years he says the birds subsist largely on these creatures. In other years as was the case in 1930, he states that they are forced to search for other food. He reports that the contents of one stomach of a bird taken near a lake was full of insects, lemmings, and gravel. A whelk (*Buccinum* sp.) was found in the stomach of another. Still another contained a cutworm (noctuid) larva, 1 adult and 1 larva of the brush-footed fly (*Argynnis* sp.), 2 *Dasychira groenlandica*, and a few crane-flies (*Tipulsa* sp.), along with the remains of a lemming. One bird was observed to contain a green berry in its bill. He cites an example of this jaeger pursuing a snow bunting and comments that these and other small birds are occasionally taken.

Larus hyperboreus Gunnerus. Glaucous Gull.

Ludwig Kumlien, in his report on the Howgate polar expedition of Arctic America (5, p. 97), noted that the glaucous gulls are extraordinarily greedy and voracious, that "nothing in the animal kingdom seems to come amiss to them. . . . Eggs, young or disabled birds, fish, and crustaceans are their common fare." He states further that they are very fond of feeding upon seal carcasses.

Results obtained in the present investigation of six well-filled, and one other stomach collected in July between 73° and 75° north latitude and 15° and 17° west longitude, and three stomachs taken in the same month at Cape York, northern Greenland, along with two taken in August at Dalrymple Island, northern Greenland, bear out this bird's reputation of being a scavenger and quite an omnivorous feeder. The results also suggest that depredations upon other bird life may at times be serious. Of the number of birds collected, seven of the full stomachs were from adults and four from juveniles.

Characteristic of most other species, the juvenile birds had consumed a much larger variety of foods than had the adults. Remains of other birds were also more numerous in the juvenile stomachs, suggesting that these birds had been hatched in the immediate neighborhood of other seafowl.

TABLE 1.—THE FOOD OF THE GLAUCOUS GULL

	Gull (own?) feathers	Hydrozoa Acarina	Crustacea (undet.)	Copepoda	Thysanoessa inermis	Diptera larvae	Mollusca (undet.)	Mytilus edulis	Loligo	Strongylo-centrotus	Pisces (undet.)	Cottidae	Microgadus tomcod	Aves (undet.)	Aves eggs	Cepphus grylle mandti	Alle alle	Lemmus trimucronatus	Phocidae (carrion)	Algae (undet.)	Musci Poa Grass sp.	Alopecurus	Carex	Cerastium	Plant (undet.)	Species of items per Stomach
Adults																										
192873	tr[a]		tr						18		27	5	50													5
192874	tr		18				tr				3		16						63							5
192876			1										99													3
192877			1								2						96								1	4
197979	tr		tr							tr		98						1				tr		tr	1	7
197980	tr		tr								15	85													tr	4
197981														100												1
Ave. %	tr		2.9				tr		2.6	tr	6.7	26.8	23.6	14.3			13.7	0.1	9			tr		tr	0.3	4.1
Juveniles																										
192871	tr		10	tr	15								75													4
192872	tr		1										99													2
197982	tr					tr		1						38	2	25	25			6			1		2	11
197983		tr								1				88	2					2	3	1			3	12
Ave. %	tr	tr	2.8	tr	3.7	tr		0.3		0.2			43.5	31.5	1	6.3	6.2			2	0.8	0.2	0.3		1.2	7.3

[a] Trace.

The accompanying table summarizes the food of the birds as analyzed in the Biological Survey Laboratory. Where genus only is given species could not be determined.

From the tabulation it is noted that coarse fish were first in importance with the adults, forming more than half (57.14 percent) of the total food consumed; while birds were second, amounting to 28 percent. It was somewhat surprising to find that these two items were almost of equal value with the young birds, fish (tomcod) totaling 43.50 percent, and birds comprising 45 percent. The presence of decayed seal (Phocidae) flesh confirms the bird's reputation as a scavenger and carrion feeder. The kelp and other plant substances taken by the young birds were taken incidental to the process of learning to feed and forage for themselves.

Pagophila alba (Gunnerus). Ivory Gull.

Only one heavily gorged stomach and gullet of the ivory gull, taken at latitude 74°05′ north and longitude 17°15′ west, was submitted for examination. Fragments of a tomcod made 1 percent of the meal, while the remaining 99 percent consisted of fragments of soft-bodied crustaceans as follows: 115 schizopods (*Thysanoessa inermis*), 95 percent; 5 amphipods (*Apherusa glacialis*), 1 percent; copepods, trace; other undetermined crustaceans, 3 percent.

Rissa tridactyla tridactyla (Linnaeus). Atlantic Kittiwake.

The single stomach of the Atlantic kittiwake, taken June 22, at latitude 62°30′ north and longitude 29°07′ west was fairly well filled with fish bones, predominantly tomcod and a species resembling the Engraulidae. Ninety-nine percent of the total food content was fish, while fragments of one undetermined damsel-fly (Zygoptera) made up the remaining 1 percent. In addition there was a trace of plant fiber.

Sterna paradisaea Linnaeus. Arctic Tern.

Only three stomachs of the Arctic tern from the north Greenland seas were submitted for examination. These were collected in July between 73° and 74° north latitude and 15° and 17° west longitude. These contained 33.67 percent fish, mainly tomcod (*Microgadus tomcod*); 65.67 percent soft-bodies crustaceans, mainly schizopods (*Thysanoessa inermis*); and a fraction of one percent of vegetable debris. One of these 3 birds was a juvenile that had fed solely on crustaceans, mostly *Thysanoessa inermis.*

Uria lomvia lomvia (Linnaeus). Brunnich's Murre.

Of seven stomachs collected in July 1931, between 72° and 73° north latitude and 13° and 18° west longitude, only three were well-filled. On the second expedition two birds of this species, collected at Parker Snow Bay, western Greenland, were submitted—only one being full. On the third arctic trip, 34 additional birds were collected near Hudson Strait, Resolution Island and Salisbury Island. Of these, 31 were sufficiently full to be used in the computation of food percentages.

From an analysis of these stomachs it is evident that Brunnich's murre

subsists principally on but few species of items. One amphipod species (*Themisto libellula*) occurred in all but one stomach and comprised 90.37 percent of the entire food consumed. Nearly two-thirds of the birds had taken this large amphipod to the extent of 100 percent of their meals, a number consuming no fewer than a hundred individuals. In a few of these stomachs other items occurred, but amounted to only a trace in the food. Other amphipods amounting to 1.40 percent included *Gammarus locusta*, *Pseudalibrotus nanseni*, and *Gnathia maxillaris*. The schizopod (*Thysanoessa inermis*) was apparently acceptable when available, as one murre had consumed more than 125 of these creatures, comprising 87 percent of its meal. But four of the birds had fed on these crustaceans and in total they formed 5.51 percent of the entire food intake. Undetermined soft-bodied crustaceans formed 1.20 percent, and in the aggregate, crustaceans formed 98.48 percent of all food consumed by the 35 birds. Fish, mostly sculpin (Cottidae), were fed upon by three birds and formed 1.06 percent of the food. The remaining 0.46 percent of the average meal consisted largely of polychaete worms, probably Nereidae. While their mandibles occurred in 9 stomachs, they usually formed but a trace in the food. Plant fiber occurred as a trace in two stomachs.

The principal items noted in the stomachs but not figured in the computations included squid (*Loligo* sp. which formed the principal item in one stomach one-tenth full), undetermined crustaceans, and fish.

Alle alle (Linnaeus). Dovekie.

Seven well-filled stomachs with five full gullets from dovekies collected on ice floes early in July from the north Greenland polar seas (between lat. 72° and 74° N. and long. 13° and 18° W.) were available for the present study. They reveal that this species shares the well-known propensity of many northern sea birds to feed extensively on soft-bodied crustaceans, as all but a mere trace of food in each of two stomachs consisted of these small aquatic creatures. One stomach contained a few fragments of fish bones and another a trace of an unidentifiable bone. A common and apparently an easily obtainable schizopod (*Thysanoessa inermis*), constituted the dominant item in all the gullets and in five of the stomachs, averaging 57.86 percent of the total food consumed by the seven birds. One bird had devoured no fewer than 133 of these reddish shrimp-like creatures while other stomachs showed remains of 75, 56, 53, and 33, respectively. Amphipods (Hyperiidae, *Gammarellus* sp. and *Themisto libellula*) amounted to 16.57 percent of the total, while fragments of unidentifiable crustaceans, probably consisting largely of the schizopods and amphipods herein listed, made up the remaining 25.57 percent of the total food consumed. It was interesting to note that a trace of feathers was found in four of the seven stomachs.

Cepphus grylle grylle (Linnaeus). Black Guillemot.

If the two available July stomachs of the black guillemot can be taken as a criterion, its summer food in the North Atlantic consists of an unusually high percentage of fish. The two stomachs contained 79.5 percent tomcod (*Microgadus tomcod*), 12 percent undetermined fish bone fragments, and 8.5 percent fragments of amphipods and undetermined crustaceans.

Cepphus grylle mandti (Mandt). Mandt's Guillemot.

Five stomachs of Mandt's guillemot were obtained from North Star Bay (lat. 76°33′ N.) and Dalrymple Island, northern Greenland and Wolsten-

holme, western Greenland. Of these, three were juvenile birds two of which contained but little food. The other juvenile stomach being but one-fifth full, had made 10 percent of its meal on fish, 10 percent on the gastropods (*Margarites* sp.), 8 percent on undetermined gastropods, 15 percent on the crustacean, *Harpacticus uniremis*, 25 percent on amphipoda, including *Pseudalibrotus litoralis* and Oedicerotidae, and 32 percent on undetermined crustaceans, probably mostly amphipods. The other juvenile birds had taken fish, squid, crustaceans, gastropods, annelid worms, and plant fiber.

The two adult birds, while consuming much of the same kinds of food, had subsisted more heavily on fish. One bird had consumed 14 sculpins (Cottidae), representing 3 species. Undetermined fish comprised 4 percent of the total while crustaceans, including *Spirontocaris polaris*, *S. fabricii*, *S. gaimardii*, *Harpacticus uniremis*, and *Amenophia peltata*, constituted 37 percent. Bivalves, squid (*Loligo* sp.), and annelids each formed 0.50 percent of the total.

As would be expected, the two races of guillemots are similar in their food habits.

Hantzsch (4, p. 90) states that "six stomachs [of Mandt's guillemot] contained in four cases fish remains, one digested crustacean remains, unmistakable prawn remains, one *Gammarus* and one small snail." Bent (2, p. 164) asserts that "the food of Mandt's guillemot seems to consist mainly of small fishes, crustaceans, and other soft-bodied sea animals."

Corvus corax principalis Ridgway. Northern Raven.

The stomachs of two northern ravens, one taken near Parker Snow Bay and the other at Dalrymple Island, furnish evidence that this northern race is as predacious and omnivorous in its food tendencies as any of its relatives farther south. The stomach contents from the two meals are as follows: No. 1. Parts of 1 chinch bug (*Nysius groenlandicus*), trace; fragments of 5 horsefly pupae (Tabanidae), 1 percent; bird egg fragments, 2 percent; bird feathers and bone fragments not positively identified, but possibly from the dovekie (*Alle alle*), 10 percent; carrion and hair fragments of reindeer (*Rangifer groenlandicus*), 40 percent; other (?) carrion, 6 percent; moss plant fiber of 2 species, 1 percent; 88 berries and 125 additional seeds, fruit pulp, floral parts, and leafy fragments of the cowberry (*Vaccinum* [? *vitis-idaea*]), 26 percent; 20 berries, fruit pulp, and 8 additional seeds of the crowberry (*Empetrum nigrum*), 8 percent; plant fiber and floral parts of bent grass (*Agrostis* sp.), 1 percent; plant fiber and floral parts of meadow grass (*Poa* sp.), 1 percent; plant fiber of undetermined grass (Gramineae), trace; seed fragments and plant fiber of sedge (*Carex* sp.), 1 percent; leafy fragments of a heath, possibly *Cassiope* sp., trace; undetermined plant fiber, 3 percent. No. 2. Parts of bird, undetermined, 15 percent; fragment of bird egg, about the size and color of that of a duck, 1 percent; fragments of mammalian carrion, 10 percent; fragments of an undetermined insect, trace; fragment of mollusks, trace; 9 berries and 11 additional seeds of the crowberry (*Empetrum nigrum*), 60 percent; moss plant fiber, 1 percent; undetermined plant fiber, 13 percent.

Mustela arctica arctica (Merriam). Weasel.

But one partly-filled stomach of this weasel was available for laboratory study and it contained fragments of a single item—a lemming mouse (probably *Lemmus trimucronatus*).

Citellus parryii parryii (Richardson). Hudson Bay Ground Squirrel.

Five stomachs of the Hudson Bay ground squirrel show that, like its more southern congeners, it is primarily a vegetarian. While a fairly large number of plant foods were consumed, two items—vetch (*Astragalus* sp.) and sedge (*Carex* sp.)—appeared in each stomach examined, and formed 73.40 percent and 14.20 percent respectively of all food taken. Smartweeds (*Polygonum* sp.) formed 8 percent, while wood rush (*Luzula* sp.), rush (*Juncus* sp.) and rose (Rosaceae) formed 0.6, 0.2, and 0.2 percents respectively. Unidentified plant debris aggregated 1 percent. Other vegetable foods occurring as a trace included: Moss, grass (Gramineae), waterbuttercup (*Ranunculus* sp.), cinquefoil (*Potentilla* sp.), Labrador tea (*Ledum groenlandicum*), and blueberry (*Vaccinium* sp.).

Four of the five ground squirrels had fed to a limited extent on the larvae of craneflies (*Tipula* sp.) which averaged 2.40 percent of the food. One animal also had the remains of fish from a preceding meal in its stomach. This, however, formed but a trace of the total food.

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BOTANY.—*Three new grasses from Polynesia.*[1]

Jason R. Swallen, Bureau of Plant Industry.

The following new species were in a large collection of grasses recently received for study from the Bernice P. Bishop Museum, Hawaii. One was collected on the island of Rapa, one on Raiatea, Society Islands, and the other on Aiwa, Fiji Islands.

Aristida aspera Swallen, sp. nov.

Perennis; culmi dense caespitosi, erecti, nodis geniculati, asperi, 40–60 cm alti, ramis dense fasciculatis; vaginae internodiis elongatis breviores, scaberulae; ligula 0.2 mm longa; laminae planae vel involutae, flexuosae vel falcatae, 2–8 cm longae, 1–2 mm latae, glabrae; paniculae 3–10 cm longae, ramis appressis paucifloris remotis; spiculae appressae vel divergentes;

[1] Received February 14, 1936.

glumae mucronatae, 1-nerves, prima 4.5 mm longa, secunda 6.5 mm longa; lemma 7–8 mm longum, glabrum, callo 0.5 mm longo, dense piloso; aristae 7–9 mm longae, teretes, scabrae.

Perennial; culms in dense hard clumps, erect from short knotty rhizomes, sometimes geniculate at the nodes, 40–60 cm tall, somewhat flattened, minutely nodulose roughened, freely branching from all the nodes, the branches often in dense fascicles; sheaths much shorter than the elongate internodes, scaberulous; ligule minutely lacerate, 0.2 mm long; blades flat, becoming involute, especially toward the tip, firm, more or less flexuous or falcate, 2–8 cm long (usually less than 5 cm), 1–2 mm wide, glabrous; panicles 3–10 cm long, the branches rather distant not overlapping, few-flowered, appressed; spikelets appressed to somewhat spreading, the pedicels 2–7 mm long; glumes mucronate, 1-nerved, the first 4.5 mm, the second 6.5 mm long, glabrous; lemma 7–8 mm long slightly narrowed toward the tip, glabrous; callus 0.5 mm long, blunt, rounded, densely short-pilose; awns 7–9 mm long terete, scabrous, equally spreading.

Type in the Herbarium of Bernice P. Bishop Museum, collected on grassy slopes of Atanui Valley, altitude 100 m, Rapa, Polynesia, July 24, 1934, by F. R. Fosberg (no. 11620). Duplicate type in the U. S. National Herbarium.

Aristida aspera is related to *A. caput-medusae* Domin which has a shorter panicle (3–6 cm long) with short, approximate, abruptly divergent branches, and smooth culms. Locally called "tine."

Garnotia mucronata Swallen, sp. nov.

Perennis; culmi dense caespitosi, 10–30 cm alti, glabri; vaginae glabrae internodiis longiores; ligula truncata 0.3 mm longa; laminae planae, lanceolatae, pungentes, glabrae, 2–6 cm longae, 2–6 mm latae, marginibus scabris; panicula 4–12 cm longa, stricta, ramis fasciculatis appressis, ad 3 cm longis; spiculae binae 4–5 mm longae basi breviter pilosae; glumae 4 mm longae; 3-nerves, acutae vel acuminatae; lemma 4 mm longum, 3-nerve, glabrum mucronatum vel breviter aristatum; palea hyalina lemma aequans.

Perennial; culms densely tufted, erect, 10–30 cm tall, glabrous; leaves crowded toward the base in a dense cluster; sheaths rounded on the back, glabrous, the lower ones short, overlapping, the uppermost elongate; ligule hyaline, truncate, 0.3 mm long; blades flat, or the margins inrolled, firm, lanceolate, sharp-pointed, 2–6 cm long, 2–6 mm wide, glabrous, the margins scabrous; panicle 4–12 cm long, strict, the branches in rather distant fascicles, appressed, the lowermost as much as 3 cm long; spikelets paired, 5 mm long, including the awn, the hairs at the base short and inconspicuous; pedicels triangular, unequal, the lower about 1 mm long, the upper 2–3 mm long; glumes equal, 4 mm long, acute or acuminate, 3-nerved, the nerves of the first glume scabrous, those of the second glume nearly glabrous; lemma firm, 4 mm long, 3-nerved, glabrous, awn-pointed or awned, the awn not more than 1.5 mm long; palea thin, hyaline, equaling the lemma.

Type in the Herbarium of Bernice P. Bishop Museum, Hawaii, collected on a high moor, Temibani Plateau, alt. 700 m, Raiatia, Society Islands, Oct. 5, 1934, by Harold St. John (no. 17295). Duplicate type in the U. S. National Herbarium. Endemic to Raiatea.

Two other endemic species of *Garnotia* have been described from Raiatea, *G. raiateensis* Moore and *G. depressa* Moore. In the first of these the blades are as much as 8 cm long and not more than 4.5 mm wide, and in the second the blades are involute, not more than 3.5 cm long, while the blades in *G. mucronata* are flat, comparatively short and broad, not more than 6 cm long and as much as 6 mm wide. Furthermore the lemmas in *G. mucronata* are awnless or nearly so whereas those of *G. raiatensis* and *G. depressa* bear slender awns 4–6 mm long.

Another collection, St. John 17298, from the type locality, also belongs to this species.

Eragrostis scabriflora Swallen, sp. nov.

Perennis; culmi erecti dense caespitosi, graciles, simplices vel ramosi, 20–60 cm alti, glabri; vaginae internodiis breviores, glabrae, in ore dense pilosae; ligula truncata lacerata 0.3 mm longa; laminae erectae vel adscendentes, subinvolutae, 5–15 cm longae (inferiores reductae), infra glabrae supra scabrae; paniculae 3–15 cm longae terminales et axillares ramis solitaribus appressis, ad basin dense floriferis, ad 2 cm longis; spiculae 6–18-florae appressae; glumae acutae 1.5 mm longae; lemma 2 mm longum subacutum, minute scabrum; palea lemma aequans carinis breviter ciliatis.

Perennial; culms erect, densely tufted, slender, wiry, simple or branching from the middle nodes, 20–60 cm tall, glabrous; sheaths much shorter than the internodes, glabrous with a conspicuous dense tuft of hairs at the mouth; ligule truncate, finely lacerate, 0.3 mm long; blades firm, erect or ascending, 5–15 cm long, the lowermost much reduced, flat or loosely folded, smooth below, scabrous and with a few long hairs at the base on the upper surface; panicles 3–15 cm long, the branches solitary, appressed, densely flowered from the base, rather distant in the lower part of the panicle, becoming approximate toward the summit, not more than 2 cm long; spikelets short-pediceled, appressed to the branches, 6–18 flowered (usually 10–12 flowered), the rachilla continuous; glumes acute, 1-nerved, about 1.5 mm long, scabrous on the keel; lemmas 2 mm long, subacute, minutely scabrous, more so on the nerves; palea persistent, obtuse, a little shorter than the lemma, shortly ciliate on the upper half of the keels.

Type in the Herbarium of Bernice P. Bishop Museum, Hawaii, collected on "bare spots in wooded basin and on limestone ridges, alt. 25–40 m, Aiwa (E)," Fiji Islands, August 30, 1924, by E. H. Bryan, Jr. (no. 528). Duplicate type in the U. S. National Herbarium.

This species has also been collected "on bare hillsides (dry) and moist hollows (luxuriant), alt. 10–60 m, . . . Olorva," Fiji Islands (Bryan 520).

This grass is apparently the one which Summerhays and Hubbard[2] refer to *E. elongata* (Willd.) Jacq. In that species, however, the lemmas are smooth and abruptly acute, the panicle branches are longer, scarcely densely flowered, and usually spreading. The sheaths also lack the tuft of hairs at the mouth which is a conspicuous character of *E. scabriflora*.

[2] Summerhayes, V. S. and Hubbard, C. E. *A supplement to the grasses of the Fiji Islands.* Kew Bull. Misc. Inf. **1930**: 262. 1930.

PLANT PHYSIOLOGY.—*Inhibition of arsenic injury to plants by phosphorus.*[1] ANNIE M. HURD-KARRER, Bureau of Plant Industry. (Communicated by M. A. McCALL.)

The inhibiting effect of sulphur on the absorption of selenium by wheat, and the quantitatively reproducible relation between the two elements at any given degree of injury to the plant,[2] suggested a search for other pairs of elements similarly related. It appeared from the quantitative nature of the interrelationship that the phenomenon might be a simple mass effect resulting from the inability of the plant to differentiate between the two elements, because of their chemical similarity, in the processes of absorption, translocation and synthesis. The possibility of a generalization covering other similarly related pairs of elements was then apparent.[3]

Reasoning by analogy, from the positions of selenium and sulphur in Group VI of the periodic table, the first pair of elements chosen for investigation were arsenic and phosphorus, which occupy corresponding positions in the adjacent Group V.

The experiments were conducted with wheat seedlings germinated on blotters and transferred to flasks containing 600 cc of nutrient solution. Three different nutrient solutions were used, containing equal concentrations of calcium, magnesium, potassium, sulphur, nitrogen, and iron but with differing concentrations of phosphorus, viz., 10, 60, and 120 parts per million as calcium monophosphate. The calcium was equalized by varying the amounts of calcium chloride. Control plants grown in these solutions were alike, showing that the differences in chlorine and phosphorus were insufficient to visibly affect growth over the period of an experiment—about two weeks.

In several successive experiments it was found that arsenic added to these solutions at a rate of 30 p.p.m. as sodium arsenate killed the plants where only 10 p.p.m. of phosphorus was present, injured those with 60 p.p.m. of phosphorus, but hardly affected those with 120 p.p.m. of phosphorus. These results are in conformity with the hypothesis proposed to explain the selenium-sulphur antagonism, namely, inhibition of toxicity by the presence of an excess of a chemically similar non-toxic element as a simple mass effect.

In the first two experiments the pH values of the nutrient solutions

[1] Received March 2, 1936.

[2] HURD-KARRER, ANNIE M. *Selenium injury to wheat plants and its inhibition by sulphur.* Jour. Agr. Research **49** (4): 343–357. 1934. *Factors affecting the absorption of selenium from soils by plants.* Jour. Agr. Research **50** (5): 413–427. 1935.

[3] HURD-KARRER, ANNIE M. *Plant physiology involved in the problem of the selenium disease of livestock.* This JOURNAL **25**: 335–336. 1935.

were 4.2, 3.9, and 3.6, respectively, for the low-, medium- and high-phosphorus levels. In the third experiment, the reactions were adjusted to pH 7.3, 6.2, and 6.5, respectively, by using one to two drops of strong sodium hydroxide. Acidity of the solutions was therefore not a factor in the antagonism.

Repeated attempts to inhibit arsenic injury to plants in the local clay loam by additions of phosphate have been unsuccessful. However an inhibiting effect was obtained in a sandy loam. These results suggest that phosphate applications will reduce or prevent arsenic injury to plants where the type of soil is such as to permit the phosphate to remain available. Such an effect of phosphorus might be of considerable importance in areas having soils contaminated with injurious concentrations of arsenic from sprays.

Preliminary results indicate a corresponding relationship between rubidium and potassium, the second pair of elements selected for study from their positions in the periodic table. Into the picture might possibly be fitted also the well-known calcium-magnesium antagonism. Other combinations such as calcium with strontium and with barium are being investigated.

ENTOMOLOGY.—*A new Ecuadorian fleabeetle injuring crucifers (Coleoptera: Chrysomelidae).*[1] H. S. Barber, Bureau of Entomology and Plant Quarantine.

Prof. F. Campos R. recently submitted a sample of an apparently new species of green *Disonycha* with the statement that its larvae, in great numbers, cause damage to various kinds of cruciferous plants at Guayaquil, Ecuador. An earlier sample from the same place and observer, received in January 1918, and another sample labeled as from Chira, Peru, May 1928, G. N. Wolcott, are believed to be the same species, but host-plant records do not accompany these specimens. No description applicable to these samples has been found, and in order that a name may be available for the species a brief diagnosis is here offered together with notes from comparison with its near relatives.

Disonycha camposi, n. sp.

Length 5 mm; width 2.4 mm. Black with bluish reflection; the elytra metallic green, the occiput, pygidium, last ventral abdominal segment, distal parts of femora, and lower surface of the basal two (or three) antennal segments, yellow. Habitat: Ecuador and Peru.

Similar to *D. laevigata* Jacoby in shape, size, sculpture, and color of

[1] Received January 15, 1936.

elytra but differs in genitalic details as well as in the melanic suppression of the bright yellow color of the body and appendages, vestiges of this yellow color remaining on the basal antennal joints and the apices of all femora as well as in a transverse oval spot on top of the head and another involving the pygidium and most of the last visible sternite. The pronotum and propleurae as well as the metasternum are shining black; the first four visible sternites together with the meso- and meta-pleurae are black, opaque and clothed with fine appressed whitish pubescence. The aedeagus is of similar form and curvature to that of *laevigata* but darker brown in color of integument, shorter and more explanate apically, and the concave orificial plate is broadly truncate at apex in the type, with deceptive brown coloration suggesting apical bifurcation, whereas in *laevigata* this concave orificial plate is more attenuate and acutely pointed at apex with a brownish median area which is narrowly produced and rounded apically. The aedeagus of the also very similar *D. collata* (Fab.) resembles the above in profile, curvature, and outline, and the orificial plate displays a similar apical bifurcation of the brown sclerotization but its apex is laterally compressed, elevated and prolonged into an erect lamella. In a paratype from Peru the apex of the orificial plate is less truncate and suggests a slight unfolding of the adjacent part of the normally invaginated internal sac, the structure of which seems not to have been investigated in any species of *Disonycha*. Without such investigation the current standards of specific, subspecific, or synonymic status of available specific names can be little more than temporary opinion.

D. camposi may also be closely related to the two Colombian species, *D. exima* Harold 1876, which, it has recently been suggested, may be a prior name for *laevigata* Jacoby 1897, and to *D. steinheili* Harold 1876, but these two forms appear, from the original descriptions, to be larger and to have the pronotum and undersurface ferrugineous or testaceous.

Type ♂, allotype ♀, and eleven paratypes in the collection of the United States National Museum.

The selected holotype is one of ten specimens submitted from Guayaquil by Prof. Campos, eight of them about the end of 1917 and two in April 1935, the latter as adults of larvae injuring crucifers. Three other paratypes are labeled "No. 25–28 Chira, Peru. May 1928. G. N. Wolcott Collector."

It is a pleasure to select for this species the name of the zealous Ecuadorian who has contributed much to the knowledge of the insects of his country.

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COSMOLOGY.—*The physical universe.*[1] HERBERT DINGLE, Imperial College of Science and Technology, London. (Communicated by HUGH L. DRYDEN.)

The word *universe* is used in so many senses, even within the field of scientific discussion, that it is the duty of anyone who uses the word to state what he intends it to represent. For the purpose of this lecture, *the universe* will mean the totality of physical existence; that is to say, the matter and energy existing in space considered as a whole. In using this expression, I wish at present to leave open the questions whether space is infinite, and whether if so, it contains an infinite amount of matter. Whatever the answers to these questions, we can still discuss the universe because even infinity can be treated *as a whole;* the infinite is not necessarily the indefinite. A simple example of this may be helpful. The series of numbers is infinite and it is therefore impossible for all numbers to be thought of individually in a lifetime: nevertheless, when a word is uttered we know immediately whether it represents a number or not. 6,425,814 is a number; a horse is not: it is not necessary to go through the series member by member to verify this. Hence infinity is not inapprehensible: we can make assertions about it and distinguish its contents from what lies outside it. It is the character of the whole, and not the catalogue of the parts that will be the subject of our discussion. As we shall see, the modern investigation of the universe is sometimes inconsistent in this respect: it professes to speak of the whole, but does so in terms incompatible with its profession. That, however, is an anticipation.

There is another preliminary remark to be made. A complete discussion of the physical universe would include an account of its mechanical and thermal properties, for both of these are physical in character. Time will not permit of this, however, and, as a matter of fact, in the present state of science, these two aspects of the subject are quite sharply divided. We can describe the mechanical properties of a system (whether or not it is the universe I will not presume to

[1] The sixth Joseph Henry Lecture delivered before the Philosophical Society of Washington on Saturday evening, February 1, 1936. Received February 11, 1936.

say), including its history from a hypothetical beginning to a hypothetical end, without any reference at all to the exchange of heat between its parts which is so important from the physiological point of view, for instance; and in such descriptions we usually speak of "the universe" without pausing to remark that it is only the mechanical aspect of the universe that we are considering. It is to that aspect that I shall confine myself in this lecture. Problems concerning the alleged *running-down of the universe,* important as they are, will be outside our scope.

The universe has come prominently to the fore in astronomical discussions in the last few years, for reasons which we shall see, but it would be a mistake to regard the study of the universe as essentially a modern subject. It is, in fact, almost the most ancient of subjects, and has undergone many vicissitudes in the course of scientific history; and one of the chief objects of this lecture is to place the modern developments in a historical setting. There is a common idea that science, in its gradual progress, has at last, for the first time, caught a glimpse of the universe, its previous history having been concerned entirely with the partial aspects of things presented to us by the contents of our own neighborhood. That is emphatically not the case. On the contrary, there is exhibited throughout history a remarkable proneness among investigators to regard their horizon as the boundary of existence, and the annals of astronomy show us that no sooner does man realize that what he once thought was the whole is only a part, than he immediately invests the larger conception to which he has attained with the same illusory finality that formerly distorted the old. This is not a characteristic of the past only. Many modern investigators are as sure as ever their forerunners were that they have at last discerned the universe. It is largely in order to combat this attitude that I have elected to treat the subject historically, and if I say some things that have been familiar to you from childhood, you will understand that I do not say them in order to convey information, but to indicate the proper background against which to see more modern ideas.

Early astronomy was simply cosmology—no more and no less. The Earth was fixed at the centre of the universe, and the heavenly bodies were points on a celestial sphere or spheres which revolved regularly round the Earth. Certain complications were introduced into this mechanism to account for the details of planetary motions, but the essential point for our purpose is that the only subject of study was the whole system of heavenly motions, and not at all the char-

acteristics of any part of the system. The time had not arrived when the Sun, for instance, could be the object of individual study. Man contemplated the whole universe, beyond which was the heaven of heavens. The scheme in principle was very simple, and all that astronomy was concerned with was its adaptation to the observations of planetary positions and its application to the practical needs of man.

These, however, proved to be surprisingly troublesome problems, and by the time of the Renaissance the elaboration of the scheme had become so complex that thoughtful minds began to suspect that some fundamental reconstruction was needed. As everyone knows, this was begun by Copernicus. The Earth was removed from its central position and placed among the planets which revolved round the Sun. The change from a geocentric to a heliocentric system is, of course, one of the greatest advances in the history of thought, extending far beyond the particular cosmological example which introduced it, but even more important than a change of viewpoint was the introduction of the idea of infinite space. With a central Earth and a spherical firmament, cosmology came to a natural end at the frontiers of theology: there was no need of infinity, and the idea was not entertained. But when the firmament was destroyed, and when, shortly afterwards, it appeared that the number of visible stars could be multiplied indefinitely by increasing telescopic power, infinity forced itself on men's attention, and the conception of an unlimited population of stars became the natural successor of the homely, limited universe of previous centuries.

With this change, astronomy, in the narrower sense of the word, was born. The universe had apparently passed beyond the reach of human thought. At the same time, its separate units had entered the reach of human thought. The telescope provided the means of studying individual bodies, and so, by force of necessity, the contemplation of the whole gave way before the examination of the part. For a brief spell cosmology ceased to exist.

It was reestablished by Newton, though in a new and previously unknown form. Newton made no attempt to grasp the aggregate of stellar existences, but he showed how to discover characteristics of the whole, even though that whole could be only partially observed. His conception of universal law restored cosmology on a new basis. He introduced the idea of principles inherent in the whole and fully expressed in every part—principles which could be deduced from partial observation and then applied to the whole. His laws of motion and

gravitation were of this character. They were statements, not of the actual, material structure of the universe, but of something which characterized the universe whatever its material structure might be. Cosmology therefore changed from a description of the body of nature to a search for the soul.

This, to be sure, involved assumptions. Before you can extend a generalization from a few observations to the whole of material existence you must postulate that the whole of material existence is in fact a *universe*, having universal characteristics. If that is not true, your laws of motion or gravitation or what not may hold in your own neighborhood, but not elsewhere. Furthermore, you must assume that your observations of a limited region are accurate enough to enable you to apply your deductions throughout the whole—possibly infinite—extent of space; you must assume, not only that there *are* universal laws, but that you have actually found them. These assumptions are worth noting because they have perhaps been too generally ignored. When, by *universe*, you mean, as in the old days, a particular system of material bodies, there are no such assumptions; cosmology is simply a statement of what you observe. But when you are forced to give up the attempt to observe the whole, but still presume to speak of a *universe* because the part you observe shows mutual relations between its parts, it is well to bear in mind that you have no longer the solid ground of primary fact beneath your feet, but an idea which, however, plausible, is still of an essentially different character from the basis of the cosmology of old.

There is no harm in assumptions, however, provided their existence is not forgotten. Accordingly, Newton's laws were accepted and their implications examined. One would hardly expect that laws which, by hypothesis, are held to be true whatever the material contents of space, would be able to give any information about those contents, yet this turned out to be possible. It became clear that if Newton's laws were actually universal, there could not be an infinite space in which stars were uniformly distributed, no matter how coarse the scale considered or how thin the distribution postulated. Since, by that time, the idea that space was infinite had become almost axiomatic, this meant that as one receded to distant places one would at last pass beyond the region of matter into emptiness: the universe of matter would be an island in an infinite ocean of vacuity. This was deduced from the fact that in a region of uniform material density, the mass of matter in a sphere centred at the Earth would be proportional to the cube of the radius, whereas the effect of distance on the gravi-

tational attraction of this mass on the Earth would be inversely proportional to the square of the radius. Hence Newton's law of gravitation would require that the gravitational effect at the Earth of the matter in such a sphere would, on the whole, increase with the radius, and so, with an infinite distribution of matter, would become infinite which was held to be contrary to observation.

I am not going to discuss this argument, because I am now simply describing history, not criticising it. It might be well, however, to say a word or two about the meaning of the coarseness of the scale of density considered. It is obvious, of course, that on the fine scale, the distribution of matter is far from uniform. The density of the Earth is much greater than that of water, and the density just outside it is almost zero. Two volumes of, say 1 cc. each may therefore contain very different amounts of matter, depending on the particular cubic centimeters chosen. If, however, we compared two volumes of, say, a billion cubic light years, we might find that they contained approximately equal amounts of matter; and if not, it might still be that much larger units of volume would give us a uniform distribution. Two volumes of 1 cubic millimetre in a sponge may differ widely in material content, for one may be in a hole and the other in the material of the sponge: two volumes of 1 cubic inch, however, would contain approximately equal amounts, so that there is a scale on which the sponge is a uniform distribution of matter. Since, in the cosmological problem we are, by hypothesis, dealing with infinite space, all finite units are infinitesimal, so we are justified in considering units of any finite size at all, and if we can find a size which will give us uniformity of density, the argument applies.

Now the conclusion of the argument was held to be unsatisfactory. It was not philosophically satisfying to think that a particular bit of space was occupied by stars while the rest was empty. Minds which had awakened from a geocentric illusion were apt to regard with suspicion any idea which tended to assign them a unique position in space, and so it was felt that somehow space ought to be filled uniformly—in other words, the universe should be homogeneous. Apparently, however, this could not be secured without abandoning the universality of Newton's law of gravitation, and this also was repugnant. No solution of the difficulty presented itself, and so the matter rested.

Meanwhile, telescopes and spectroscopes had been busy increasing the extent and accuracy of our knowledge of the contents of our own neighborhood. The solar system belonged to a vast organization of

stars which appeared to be one of many such organizations—the spiral nebulae. The evidence for this was rather slender at first, but increased later, and at the time which we have reached in the development of theoretical ideas, it had captured the imaginations rather than the intellects of astronomers. Despite definite indications that our stellar system was thinning out with distance from the Sun, as the gravitational argument required, the spiral nebulae were held to be *island universes* which, on the coarse scale, might provide the homogeneity of material distribution which instinct demanded. Insofar as the unsettled ideas of the time can be said to have presented a definite aspect, it was either that of a single system of material bodies in a surrounding infinite void, or that of a multitude of such systems with an unknown distribution throughout that void. Whichever idea was held, however, it was regarded as an idea of the universe. The possibility that what we observed was too small to be *typical* in any degree of the whole was scarcely accorded even lip-service.

Such was the position at the advent of relativity. This affected our problem in two ways. In the first place, it showed that we could not adequately consider the distribution of matter in space without considering its distribution in time also—a fact which is often falsely expressed by the statement that time and space are identical. And, in the second place, it displaced Newton's law of gravitation by another which did not prohibit the possibility that space was completely filled by a homogeneous distribution of matter. I am not going to discuss the principle of relativity itself but I want to say a few words on each of these points.

The inseparability of time and space is easier to realize in relation to the universe than in any other relation, because of the greatness of the scale. It all depends on the fact that we know of no physical means of communication between separated points of space which is more rapid than light. Between terrestrial events light passes practically instantaneously, so that we can say with sufficient exactness that a thing happens when we see it. But when we see an event on even the nearest spiral nebula, we know that that event happened nearly a million years ago. We can theoretically, if we wish, determine what terrestrial events were *simultaneous* with it, but when we are dealing with such intervals, simultaneity loses its interest. We are much more concerned with what we can see now in the nebula than with what is happening there now, which will not be revealed to us for nearly a million years. Hence the structure of the universe

at any one time is no longer the object of our investigation. Instead, we take history and structure together in a union which relates our present observations with one another and relegates to the background the results of calculations concerning conceptual simultaneous happenings. That is all that the amalgamation of time and space means, and if one thinks of it in terms of these large-scale phenomena instead of terrestrial events it ceases to be mystical and one is saved from the illusion that somehow time and space are the same, despite our knowledge that they are very different.

The possibility that space might be filled homogeneously with matter without violating known facts arises from the possibility, afforded by the new law of gravitation, that space might be finite, though unbounded. This is another of the so-called mysteries of relativity, but it is not at all incomprehensible I think, if it is approached in the right way. The difficulty which one feels is that if the matter of the universe is contained in a finite space, one can always imagine an infinite space outside that finite region, so that it is not accurate to say that *space* is finite.

Very well, let the surrounding infinite space be imagined. We then have a homogeneous sphere, let us say, of matter surrounded by infinite emptiness. This sphere, of course, consists of the stars and nebulae that we see around us, together with all that might be beyond the present reach of our telescopes; and we are somewhere in the midst of it. Now let us try to send some matter outside this region into the enveloping void. We find this impossible, because the law of gravitation is such that the matter cannot escape;[2] it always returns like a stone thrown into the air. It is possible, of course, to project a stone fast enough to escape from the Earth altogether, but the laws of motion and gravitation in the Einstein universe are such that it is impossible for the stone to get free into our imaginary void. There is nothing difficult to conceive in that: it simply means that nature provides no method of projecting a body fast enough to escape from this system of bodies which we call the universe.

We might imagine, however, that we can *see* outside the system. But that is impossible also. If we project a beam of light upwards, it will be attracted by the rest of the universe and bent back so that it cannot escape. Furthermore, if we were situated at the very boundary of our sphere we could still look upwards and see only light from stars beneath us. The stars would appear to be above us because their light

[2] I am now describing the original static Einstein universe; we will consider later the more recently conceived *expanding* universe.

would enter our eyes in a downward direction, but the stars themselves would not be there. If we travelled along their light we should go upwards a little, and then turn round until at last we should enter the star from which the light came, at a place somewhere inside the system. This also is not inconceivable; it is simply an example of a fact very familiar to everyday experience. When we see the Sun on the horizon in the evening, it has already set: its light is bent by the atmosphere of the Earth so that we see the Sun although it is already below our level. In precisely the same way, though from a different cause, the stars which our boundary observer would see above him would be below his feet.

Now let us notice two things. Since nothing—neither light nor matter—can escape from our universe, and we get no indication of anything outside, we can dispense with the notion of a surrounding emptiness. We can go on thinking about it if we like, but if so we are confusing our thought, because we can get no knowledge of it: everything we can see or know belongs to our own system of stars. Hence, since astronomers do not wish to load their minds with ideas which serve no purpose, they discard it, and call space simply the region which is accessible to observation. The surrounding infinity has no scientific existence: it is simply an illusion, necessary in an immature stage of thought, just as the propositions of arithmetic have at first to be incarnated in problems about apples or pears. When we know the principles of the problem we can dispense with the part which does not enter into the solution.

The second thing to notice is that since our hypothetical observer at the boundary of the system sees stars above him just as an inside observer does, he cannot tell that he is at the boundary. Detailed considerations show, in fact, that his view would be indistinguishable from that of the inside observer, and therefore there is nothing to be gained by saying that he rather than the other is on the boundary. The statement previously made that the stars were "beneath his feet" would mean nothing to him: that would be the appearance to a hypothetical observer outside the universe. We have already dispensed with the outside space which is all that could give a meaning to a boundary, and so it follows that there is no boundary. Wherever you are in the universe you see the same kind of spectacle and have the same freedom and limitation of movement. Hence one part of the universe is just like another: the universe is homogeneous and unbounded. It is nevertheless finite because you can, in principle, count the stars in it and get a finite number. Also, you can travel about

and, in principle, survey the whole. The whole difficulty of conceiving of finite unbounded space is therefore that of discarding artificial aids to thought: when the lesson is learned, the parable is no longer necessary.

The universe I have described is the famous Einstein universe of the early days of relativity. At that time the remarkable phenomenon of the recession of the spiral nebulae[3] was not known. It has since been discovered that these objects are receding from us (i.e., from our whole stellar system, for we are now speaking on the largest scale consistent with our knowledge) at speeds proportional to their distances: the most distant nebula now known to take part in this recession is some 230 million light-years away, and it is moving with a speed of 40,000 kilometers a second. Of course, there is much uncertainty about these measurements—not only with regard to the actual figures, but also with regard to the interpretation of the phenomena which we call *distance* and *velocity*. The velocities are measured by the displacements of spectrum lines, and these may have some unknown cause in objects so exceptional and unfamiliar as those which we are considering. Nevertheless, there is no valid reason for rejecting the ordinary interpretation. Many feel inclined to do so because of the enormous velocities involved, but that is pure prejudice. There is no reason at all why nebulae should not move at such speeds, and indeed we ought to expect that the qualities they exhibit will differ in important respects from those to which our provincial minds are accustomed. When we have, as here, to choose between exceptional behavior of bodies and exceptional laws of nature, the former is certainly the choice which is more in accord with the general practice of science. If, then, we reject unscientific expectation as a sufficient reason for doubting the motions of the nebulae, we are left with only the healthy scepticism which does not forget that it is employing speculative building material, but nevertheless goes on building.

Relativity mechanics is quite consistent with a universal nebular recession; indeed, there is a sense in which it predicted the phenomenon, though only as one among other possibilities. The mutual support of observation and theory therefore gives considerable plausibility to the idea that we are at last in touch with the universe itself, for the mechanical system which relativity describes as expanding is one which is completely self-contained. Like the rejected Einstein universe, it has no space outside itself which has any scientific mean-

[3] The term, *spiral nebulae* is used to denote the extra-galactic nebulae generally· many of them, of course, do not show a spiral structure.

ing, notwithstanding the fact that we find it difficult to conceive how a system can expand when there is nothing for it to expand into. This difficulty appears to be at bottom a play upon the word *nothing*, for actually *nothing* is just what we want to make the idea credible; if there were *something* there, expansion might be prevented. To put it in another way, space becomes significant only when the system has expanded so as to include it: whatever is not included at any instant has no significance, for it is quite without influence on the system at that instant. At a later instant, when the system contains more space, we are inclined to think of the added amount as having previously existed outside, but we cannot identify that *added* amount. It is not something which we can label and say, "This part has been in the universe all the time, and this part has only just come in." All we can discover from observation is that if we measure the distance between two nebulae at two different instants, the distance will be greater at the later instant. We do not observe a boundary constantly moving outwards; we simply observe nebulae receding all around us. Consequently the *expansion* of the universe is only a picturesque expression of a characteristic of our measurements. If we try to picture the universe as an isolated system from which we can withdraw and observe it as a whole, we feel compelled to insist on a surrounding space in which it can be isolated. If we give this up and keep to the actual facts of the case, which are simply concerned with relations between our measurements, our difficulty vanishes.

I think the difficulties of understanding the modern views of space are enhanced by the idea of *space curvature*, which is so commonly talked about. The fact is that this is a purely mathematical expression. When we are dealing with a simple two-dimensional surface, like that of the Earth, situated in our ordinary, familiar three-dimensional space, a certain mathematical function of our survey of the surface happens to represent our ordinary idea of its curvature, and for that reason the function is called the curvature. Now our imaginations will not extend to a three-dimensional "surface" situated in a four-dimensional continuum, but our mathematics can easily be generalized to include any number of dimensions, so that mathematically we can speak of the curvature of this three-dimensional "surface" which is our ordinary space. But it is a great mistake to try to picture this, for it is quite impossible. All we can imagine is the set of measurements we make and the relations between them, and it would be far better to speak of those imaginable things than to transfer a quite legitimate mathematical metaphor into a sphere of thought where it has no

place. Space is curved only in a mathematical sense; in terms of what we ordinarily mean by curvature, the idea is meaningless.

The present idea of the expanding universe thus owes its existence to the impact of observation on a set of possibilities offered by relativity mechanics. Theoretically, the static Einstein universe is possible, provided that space is finite, though unbounded. The expanding universe, however, is subject to less limitation. Either finite or infinite space is permissible if it is expanding, for there is then no imperative necessity for every ejected body to return to the system; it all depends on the conditions of the expansion. We may therefore have a finite amount of matter homogeneously distributed in a region in such a way that its parts are continually getting further and further apart; or we may have an infinite amount of matter similarly distributed. Which we actually have we do not know. Possibly we have neither, for the distribution of matter may not be homogeneous, and in that case, many other possibilities are open. With our present limited knowledge, however, we prefer to think that there is no unique region of space, such as the place of greatest density would be, and so far as observation has extended, our preference is justified. We must not forget, however, that all that we can yet observe may be not only a very small part of the whole, but a part which is not large enough to show anything but local peculiarities. A surveyor of a mountain range would hardly discover the true spheroidal form of the Earth by generalizing his observations. It therefore remains quite possible that the universe is static on the large scale, and that the expansion we observe is local—not in space alone, but also in time. In that case it may later cease and turn to a contraction—the whole universe, while showing these minute disturbances, remaining majestically quiescent on the grand scale.

There is a tendency to suppose that this cannot be because, as Eddington has shown, the static Einstein universe is unstable, and a small disturbance would necessarily make it expand or contract. This argument, however, seems to me to work in just the opposite direction. If we are actually considering the whole universe, then there is no difference between stability and instability. A mechanical system is stable when, if it is very slightly disturbed by some external force, it tends to recover its former state; and it is unstable when, in the same circumstances, it tends to depart further from its former state. Now what Eddington has shown is that if we have an Einstein universe, one such disturbance would necessarily destroy its static state and set it expanding or contracting, and he concludes that such

a disturbance occurred sometime in the past. But if he is actually dealing with the universe, such a disturbance cannot happen because there is, by hypothesis, nothing outside to cause it: if there is something outside (i.e., not outside a region of space but outside the content of the definition of the mechanical system), then the system is not the universe. Insofar, then, as relativity mechanics or astronomical observation indicates that the system of spiral nebulae has expanded through the disturbance of a primordial Einstein system, it indicates also that that system was not the universe but only a part thereof which was affected by the rest. It therefore argues in favor of the idea that our expanding system of nebulae is merely a local unit in a larger universe.

This is one of several examples of the difference between the mechanical problems of the universe and those of any partial system. The whole of physical nature has unique characteristics arising simply from the fact that it is the whole and not a part, and nothing is easier than to overlook this difference and apply "established" mechanical laws where properly they are inapplicable. Another example is the inapplicability of the ordinary process of *abstraction*. We can abstract laws of motion from moving planets, falling stones, rolling billiard balls, swinging pendulums, and so on, by ignoring everything that is not common to all such things, but we cannot ignore anything in the universe. There is only one universe, and therefore there is no difference between essential and accidental characteristics: they are all one. Again, all considerations of probability are irrelevant. It is quite illegitimate to seek the most probable behavior of a universe by considering many universes, as in statistical mechanics we seek the most probable behavior of an assembly of molecules by considering many such assemblies. Many universes are not merely actually non-existent; they are logically non-existent, for the universe is by definition the whole. This fact also has been conspicuously overlooked, I think, in certain considerations of the character of the universe. And, as a final example, the universe is the only mechanical system which has no boundaries, and therefore the problem of the universe differs from all other mechanical problems in having no boundary conditions.

For these reasons, I do not feel greatly concerned about the most prominent enigma in the present position of the universe problem—namely, the very short time-scale by which we appear to be faced. The recession of the nebulae can be extrapolated backwards to a time when all the matter forming them was more or less together in one place, and that time is no longer ago than about 2×10^9 years—which

is smaller than is convenient to explain certain characteristics of stellar astronomy. Certainly the problem is a very pertinent one, and deserving of all consideration, but it seems to me that whenever the requirements of the theory of the universe come into conflict with the requirements of special studies, it is the former that is far more likely to yield. The universe itself is a postulate—it is not something we observe: and the conditions of its study are so peculiar and so little apprehended as yet compared with those of partial problems that it seems fantastic to allow wide extrapolations from the most difficult of observations to dominate the detailed studies on which scientific laws themselves are founded. The study of the universe is helpful if it lifts our minds above the limitations imposed by undue specialization, but it becomes harmful if we allow it to fetter us still further in our consideration of the actual.

GEOPHYSICS.—*Some aspects of geophysical cycles.*[1] J. BARTELS, Department of Terrestrial Magnetism, Carnegie Institution of Washington. (Communicated by L. R. HAFSTAD.)

The common geophysical cycles of everyday experience can be connected with the rotation of the earth (solar and lunar diurnal-variations) or its revolution (annual variations), with the sun's rotation (27-day recurrence in terrestrial-magnetic activity, etc.), or with some physical resonance-effect depending on the form of the essential differential equation (water-waves, seiches, seismic waves, etc.). The familiar up and down in the records of many geophysical and other phenomena (atmospheric pressure, temperature, rainfall, tree-ring widths, business indices, mortality, etc.) has challenged many efforts to trace cycles of other periods than a day or a year. The outcome of this extensive search, made with analytical, graphical, optical, or mechanical procedures, is a bewildering variety of cycles claimed, but all are of a controversial nature. This curious result seems to be due to inadequate methods of research. A study of typical cases is proposed, leading to an outline of a statistical theory of geophysical and cosmical periodicities. Before the cyclic effect has been established in the series of observations by statistical methods, a physical explanation cannot be attempted.

The usual mathematical analysis gives at the same time too much

[1] The subject of this paper formed the basis of a more extended address under the above title by the author at the 1087th meeting of the Philosophical Society. Received January 10, 1936.

and too little. The theorem of Fourier series, or the recently developed theory of almost periodic functions, assert namely that every finite series of observations can be satisfactorily approximated by a sum of sine-waves of different periods and amplitudes, and even an infinite number of such sums can be found. This purely mathematical fact does not lend any significance to each individual sine-wave. A continuation of the sum of sine-waves into the future ceases in general to fit and is therefore of no use for forecasting (example: H. Kimura's[2] analysis of relative sunspot-numbers 1750–1911; the 29 sine-terms, continued, disagree with the observed numbers since 1912[3]). A notable exception is furnished by tidal theory, in which the periods of the essential sine-waves in ocean-tides are derived from the astronomical data on the movements of earth, moon, and sun; the amplitudes and phases of these sine-waves are computed by harmonic analysis of at least one year of tide-gage observations and then used for prediction. The same holds for tides of the solid earth (experiments of Michelson and Gale).[4] Such a complete representation of the data as sums of interfering sine-waves, with periods of submultiples of a *master-period,* is the aim of many workers on cycles, but it can be misleading (example: Seasonal change of amplitude in diurnal variation of atmospheric temperature at Berlin can be interpreted as spurious *sidereal-time variation*).

The problem of cycles is only part of a more general one, namely that of the morphology of geophysical time-curves, which should comprise an adequate mathematical description of the essential features of such curves. For simplicity, only values given at equidistant time-intervals (hourly values, etc.) are considered. Such a group of values for the same quantity, regarded as a statistical population, can be submitted to the ordinary procedures for computing averages, frequency-distributions, standard deviations, etc. These statistical conceptions are mostly developed in biometry. There is, however, a fundamental difference between lists of data in biometry and the time-series of geophysical observations; successive data in the former case are mostly independent (random), while geophysical data mostly show positive conservation, that is, high values are more likely to be followed by other high values, etc. Thus, for example, if one examines the differences of consecutive random numbers he finds in them negative conservation, whereas a similar examination of

[2] Mon. Not. R. Astr. Soc. **73**: 543–548. 1913.
[3] Terr. Mag. **39**: 231–236. 1934; **40**: 215–217. 1935.
[4] Astroph. J. **50**: 330–345. 1919.

daily sunspot-numbers will reveal positive conservation. The original ordinates may be y, and the averages of h successive ordinates may be $y(h)$; the standard deviations may be $m = m(l)$ for the y, and for the $y(h)$. For random-ordinates, $m(h) = m/\sqrt{h}$; for ordinates with conservation, this is measured by $\sigma(h)$ $[m(h)/\sqrt{h})\ ]$.[2] Because $m(h) = m/\sqrt{h/\sigma(h)}$, $\sigma(h)$ is called *equivalent number of identical ordinates*, or $h/\sigma(h)$ is called *equivalent number of random-ordinates among* h *successive ordinates*. $[\sigma(2h)/\sigma(h)] - 1$ is the ordinary correlation-coefficient between successive averages. Example: Daily relative sunspot-numbers, near sunspot-maximum; for $h = 365$, $h/\sigma(h)$ is only 2.6. If $\sigma(h)$ approaches a limit σ, this might be called the *natural time-unit* for the quantity.

The usual computation of cycles is demonstrated for the lunar atmospheric tide. It begins with arranging the data in rows (individual sets) of r ordinates, and forming *average sets*, which consist of the averages of the r columns of h individual sets. The standard deviation of the individual sets may be ζ, that of the average sets may be $\zeta(h)$. In the *random-case*, in which there is no significant cycle of a period comprising r ordinates (these ordinates themselves may be random or not!), $\zeta(h) = \zeta/\sqrt{h}$; otherwise, $\sigma(h)$ can be computed as above as the square of the ratio $\zeta(h)$ to $\zeta/\sqrt{h}$, and, if significantly different from unity, denotes quasi-persistence (the analogue of conservation), measured by $\sigma(h)$, the *equivalent length of sequences*. If $\sigma(h)$ approaches a limiting value $\sigma(\infty)$, the series shows *asymptotic quasi-persistence* (example: Twenty-seven-day recurrences in terrestrial-magnetic activity, $\sigma(\infty)$ between 3 and 4). If $\sigma(h)$ is asymptotically proportional to $\sqrt{h}$, a *persistent wave* is found.

Harmonic analysis allows a refinement of this method by taking into account the conservation in the original ordinates. Individual sets of r ordinates, in the time-interval $t = 0$ to 2π, are represented by sums of terms $(a_\nu \cos \nu t + b_\nu \sin \nu t) = c_\nu \sin(\nu t + \alpha_\nu)$. In the *harmonic dial* for fixed frequency ν, an individual wave is represented by a plane vector with the rectangular coordinates a_ν, b_ν, and the polar coordinates c_ν, α_ν, or only by the endpoint of this vector; in the *generalized harmonic dial* in $(r-1)$ dimensions, the vector has the coordinates $a_1, b_1, a_2, b_2, \ldots$, and the square of its length is $c_1^2 + c_2^2 + \cdots = 2\zeta^2$. For random-ordinates, the mean c_ν^2 is about $4\zeta^2/r$, independent of the frequency; in ordinates with conservation, the mean c_ν^2 is smaller than that value for higher frequencies, and greater for low frequencies. The mean c_ν plotted against ν gives the *mean periodogram*.

Cycles with fixed period can be classified by considering *clouds of points* in the (plane or generalized) dial. The dimensions of these clouds are given by the mean harmonic amplitude, c for individual sets, $c(h)$ for averages of h sets. For random-cycles, $c(h)=c/\sqrt{h}$, that is, the clouds for averages shrink in the ratio $1/\sqrt{h}$ with respect to the origin. In case of quasi-persistence, the clouds shrink more slowly than in the ratio $1/\sqrt{h}$, namely, in the ratio $1/\sqrt{h/\sigma(h)}$, with $[c(h)/(c/\sqrt{h})]^2=\sigma(h)$. $\sigma(h)=\sigma(\infty)$ denotes asymptotic quasi-persistence. These conceptions may be illustrated nicely by examples dealing with terrestrial-magnetic activity; a number of such are treated by the author in his paper *Random fluctuations, persistence, and quasi-persistence in geophysical and cosmical phenomena*[5] where *random-walk* and *summation-dial* are used for illustration instead of shrinking clouds. A complete analysis should comprise the whole spectrum, but the actual amount of necessary calculations is reduced because of the *infective property* of quasi-persistence in cycles of adjacent periods.

Correlations between cycles in different phenomena are traced by *setting* the clouds in one dial to the same phase and turning the phases of coordinated vectors in the other dial by the same phase-angle. An example: Suicides in Berlin 1906 to 1914, compared with terrestrial-magnetic activity, full or half solar-rotations (27- or 13.5-day cycle); no appreciable correlation, contradicting the conclusions of T. and B. Düll.[6]

This statistical aspect of cycles is imposed by the fact that, instead of the carefully planned experiments in the laboratory, geophysics often provides us, so to say, with a number of large-scale experiments which all go on simultaneously, and the results of which have to be disentangled. The methods described need not be applied in detail in each case, because, after some experience, the examination of some samples will suffice for estimating the significance and the characteristics of a cycle. As to the mathematical side, the methods may be considered as a first attempt to amalgamate the ideas of A. Schuster[7] on the statistical aspect of hidden periodicities with those of Lexis[8] on super-normal and subnormal dispersion in ordinary statistical series; there is room for considerable refinement, because the formulae

[5] Terr. Mag. **40**: 1–60. 1935.
[6] Bioklim. Beibl. **2**: 24–31. 1935.
[7] Terr. Mag. **3**: 13–41. 1898; Cambridge Phil. Trans. **18**: 107–135. 1899; Phil. Trans. R. Soc., A, **206**: 69–100. 1906.
[8] H. L. Rietz, *Mathematical statistics*, 146–155 (1927).

were derived roughly as an emergency measure not only for detecting significant cycles, but even more for checking the exuberant production of cycles claimed without adequate tests, or, worse, after misleading applications of distorted *periodogram* tests.

PALEONTOLOGY.—*A new mustelid carnivore from the Neocene beds of northwestern Nebraska.*[1] C. LEWIS GAZIN, U. S. National Museum.

In the spring of 1935 the U. S. National Museum purchased from Mr. Ted Galusha of Hay Springs, Nebraska, a fossil mustelid skull from the later Tertiary of Nebraska. The specimen was found in a draw to the south of Antelope Valley, near the center of the southern half of Sec. 30, T. 31 N., R. 47 W., Dawes County, Nebraska. The deposits at this locality are believed to be equivalent to the Snake Creek beds, but the horizon represented in this series is not definitely known. The age is apparently upper Miocene or possibly lower Pliocene.

The skull is unique in comparison with living forms and is distinct from known skulls of fossil mustelids, and although comparisons with fossil forms known only from lower jaws are difficult, and perhaps unsatisfactory, an analysis of the requirements for dental occlusion apparently eliminates it from previously described genera.

Craterogale,[2] n. gen.

Type.—*Craterogale simus.*

Generic characters.—Skull short and broad; strong postorbital processes and rugged, separate temporal ridges; prominent lambdoidal crests and mastoid processes; zygomae deep, powerful, and widely expanded; infraorbital foramen of moderate size and nearly circular; basicranial region short with large bullae firmly fused to surrounding elements; bullae project markedly downward, forward, and slightly inward, with antero-externally directed foramen through projected portion; audital tube short; foramen ovale, foramen lacerum medius, and eustachian foramen closely grouped; dental formula $\frac{?\text{-}1\text{-}3\text{-}1}{\quad}$; teeth small and stout; P^3 relatively small; P^4 with small parastyle, deuterocone well forward, and without tetartocone; M^1 with elongate external portion, conspicuous parastyle, and moderately large heel which is expanded anteroposteriorly to about the same extent as the external portion; protocone of M^1 large and hypocone less prominent.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received February 17, 1936.

[2] Derived from the Greek *krateros*, strong, *gale*, weasel.

Craterogale simus,[3] n. sp.

Type.—Nearly complete skull, U.S.N.M. no. 13801, including P^3 to M^1 on both sides.

Horizon and locality.—Snake Creek (?) beds, Upper Miocene or Lower Pliocene, Dawes County, Nebraska.

Specific characters.—Only known species; size of skull approximately one-fifth larger than that of *Mephitis nigra*, but much more rugged; P^2 to M^1 about 24 mm. Other specific characteristics are not clearly discernible in the absence of additional species.

Description of skull.—The skull of *Craterogale simus* is intermediate in size between that of a fisher, *Martes pennanti*, and of a martin, *Martes americana*, but relatively much broader and more rugged than either. The skull is proportioned somewhat more as in *Mephitis*, though larger, and with a breadth suggestion of the felids.

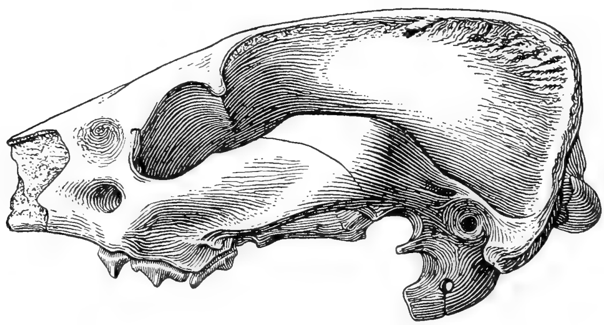

Fig. 1.—*Craterogale simus*, n. gen. and sp. Skull, type specimen, U.S.N.M. no. 13801, lateral view, natural size. Upper Miocene or lower Pliocene, Dawes County, Nebraska. Drawing by Sydney Prentice.

The rostrum is short and broad with prominent pre-orbital or lachrymal fossae. The orbital cavities, though open posteriorly, are well defined by prominent postorbital processes of the frontals and noticeable, but less developed, processes on the jugals. The anterior margin of the orbit is interrupted by a marked outward and upward projection of the lachrymal bone. Laterally the maxillae join deep and powerful zygomae. The relative development of the zygomatic arch is not approached in any of the living mustelids and its depth is actually equal to or greater than that in much larger individuals of the wolverine. On its anterior and ventral surface the zygoma shows a marked excavation, presumably for attachment of the anterior masseter lateralis. The infraorbital foramen is of moderate size, nearly circular, and terminates anteriorly above P^3. On the dorsal surface of the rostrum the premaxillae project backward between the nasals and maxillae to a point of contact with the frontals. In some mustelids, as in the Mephitinae the premaxillae apparently do not extend so far back, but in the Lutrinae, for example, both conditions are found.

The cranial portion of the skull is moderately elongate and not greatly inflated, much less so than in *Lutra* or *Taxidea*. The dorsal surface of the cranium is characterized by strong, outstanding temporal ridges, more

[3] Derived from the Greek *simos*, snub-nosed.

rugged than in *Helictis*, extending from the prominent postorbital processes and remaining separate to the occipital crest. The ridges most closely approach one another at a point slightly posterior to the postorbital constriction and are most outstanding near the occipital crest. A weak sagittal crest is present from about the postorbital constriction to the occiput.

The posterior or occipital portion of the skull exhibits heavy lambdoidal crests which extend from the temporal ridges at the top of the occiput in diverging, nearly straight lines to the prominent mastoid processes. These ridges project outward and backward to a marked degree. The paroccipital processes, just posterior and median to the mastoid processes, are not completely preserved but do not appear to have been developed so strongly as the mastoid processes. The surface of the occiput shows a moderately in flated median ridge from the foramen magnum below to the crest of the occiput. The foramen magnum and the occipital condyles are of moderate size and the surface of articulation extends entirely around the lower margin of the foramen.

The palate is broad and short, though relatively a little longer than in *Mephitis*, and shows a prominent groove on each side extending forward from the principal posterior palatine foramina. These foramina are located inward from about the middle of the carnassials, not so far forward as in the otters and skunks, nor so posteriorly placed as in the badgers. The portion of the palate extended posterior to the dentition is noticeably concave transversely and projects backward to a point about equivalent to that in *Lutra* or *Helictis*, more than in *Mephitis*, and distinctly less than in many forms such as *Tayra*, *Grisonella*, *Taxidea*, *Meles*, and the fisher, *Martes pennanti*. The width of the posterior narial opening is about as in *Mephitis* or *Conepatus*, but with no indication of the partition conspicuous in the mephitines. Between the molar tooth and the posterior narial opening, on each side of the extended portion of the palate, is a small though conspicuous process, apparently defining the antero-ventral limit of the origin or attachment of the pterygoid muscles. A similar process is present on the external surface of the pterygoid plate, on the antero-dorsal margin of the pterygoid fossa opposite the hammular process. These appear well defined in comparison with living mustelids.

Perhaps the most striking character of the skull is the extent to which the bullae project below the basis cranii. The bulla appears well inflated, relatively perhaps as much as in *Taxidea*, with a more transversely compressed portion extending downward, forward and slightly inward. Just below the inflated portion the tympanic exhibits a large foramen directed outward and forward from the medial surface. The osseous portions extending downward behind and in front of this aperture are tightly closed below but not coossified. Apparently this remarkable development on the tympanic is due to a muscular attachment along the ventral margin, possible extending back nearly or entirely to the base of the paroccipital process. In all probability this muscle was the digastricus. Such a marked development at its origin would be entirely in keeping with the unusual development indicated for the masseter and temporalis. The digastricus usually originates at the paroccipital process, but according to Windle and Parsons[4] in terrestrial carnivora it also arises "often from the contiguous paramastoid and bulla tympani." Reighard and Jennings[5] note that in the cat the digastricus originates

[4] WINDLE, B. C. A., and PARSONS, F. G. Proc. Zool. Soc. London, pp. 376–377. 1897.

[5] REIGHARD J., and JENNINGS, H. S. *Anatomy of the Cat*, p. 107, New York, 1929.

"from the outer surface of the jugular (paroccipital) process of the occipital bone, and by tendon from the tip of the mastoid process and from the ridge between the mastoid and jugular processes." This latitude for attachment in carnivora leads one to suppose that in this instance the origin of the digastricus extended well forward on the bulla. Other muscles originating in this region, with forward insertions, such as the styloglossus and stylohyoid, are not eliminated but it seems unlikely that these would be developed to the extent indicated by the process on the bulla.

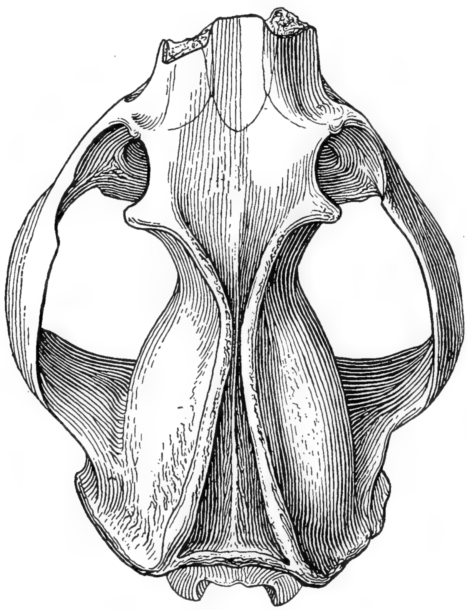

Fig. 2.—*Craterogale simus*, n. gen. and sp. Skull, type specimen, U.S.N.M. no. 13801, dorsal view, natural size. Upper Miocene or lower Pliocene, Dawes County, Nebraska. Drawing by Sydney Prentice.

The foramen enclosed by the ventral projection from the tympanic is relatively large. Its direction and position suggest that it may have carried the external carotid artery. After leaving the side of the trachea this artery turns outward, gives off various branches including the internal carotid and occipital arteries, passes deep to the digastricus and between the digastricus and styloglossus. Assuming that the muscle which has its origin on the bulla was the digastricus, the external carotid in maintaining its normal relations would have either passed through the foramen or anterior to the bulla and thence external to the styloglossus and the bones of the hyoid. If the styloglossus muscle in part originated at or near the mastoid process and the stylohyoid bone was attached in a normal position near the stylomastoid foramen then the external carotid in passing through the foramen in question would be in a position to meet these conditions with the least deviation from its normal course. The inferred course of the external carotid through the foramen which is approximately in its normal path seems likely inasmuch as the position of the artery would have been established in the tissue before ossification had surrounded the vessel. If it could be

demonstrated that the carotid ascended external to the bulla then the foramen might have been occupied by the posteriorly directed internal carotid and occipital arteries.

The jugular veins are apparently eliminated as possibilities since the internal jugular passes posteriorly from the foramen lacerum posterius and the external jugular descends superficial to the position in question. Of the nerves which pass forward from the vicinity of the foramen lacerum posterius only the ninth and twelfth, the glossopharyngeal and hypoglossal, are not entirely eliminated, but these would apparently descend to the vicinity of the pharynx and then forward to the tongue, and not outward enough to have gone through the foramen in the projected portion of the bulla.

The bullae in *Craterogale simus* are of additional interest in being so completely fused with the adjacent bone elements, apparently a strengthening associated with the muscular attachment to the bullae. Medially the bullae join the basioccipital and basisphenoid forming a nearly smooth, transversely concave surface. Postero-externally and posteriorly the prominent mastoid process and incomplete paroccipital process are separated from the bulla by an acute notch, but at the roots of these processes the mastoid and exoccipital bones are firmly joined to the bulla. Anteriorly and antero-externally the bulla is strongly united to the alisphenoid and squamosal. The anterior margin of the bulla is not curved backward dorsally to meet the alisphenoid and squamosal, and does not exhibit a transverse fissure as observed in forms having inflated bullae, such as *Taxidea*, *Gulo*, and *Martes*, but is extended forward, lapping out on the postero-ventral surface of the postglenoid almost or quite to its anterior margin (a condition noted by Matthew[6] in *Leptarctus*).

The external audital tube is short due to the inflation of the bulla, and is solidly joined to the adjacent squamosal and periotic bones, quite filling the space between the zygomatic and mastoid processes. The meatus is moderately large, nearly circular and directed outward about perpendicular to the median vertical plane of the skull, not forward as in so many of the mustelids.

The glenoid surface is well developed, with a relatively broad postglenoid process as in *Mephitis* and with the anterior margin of the fossa extended forward uniformly about as in *Martes*. The outer portion of the anterior margin is prominent but does not recurve to form a locking joint as in *Lutra* and *Gulo*.

As general in mustelids the alisphenoid canal is absent, unless its openings are entirely concealed in the recesses of the foramen rotundum and foramen ovale, which seems unlikely. The opening of the optic foramen occupies a position farther forward from the foramen lacerum anterius than in *Mephitis* but relatively not so far forward as in *Martes*. The foramen lacerum anterius and foramen rotundum are separate but placed very close together. Posterior to these and at the antero-median margin of the bulla the foramen ovale, eustachian foramen, and foramen lacerum medius are very closely grouped together. The foramen ovale opens unusually close to the eustachian foramen, closer than in *Mephitis*, and is separated from this opening and the foramen lacerum medius by a thin plate of bone which extends forward as a ridge to form the posterior margin of the pterygoid plate. The small posterior opening of the carotid canal is forward of the foramen lacerum posterius about one third of the distance to the foramen lacerum medius. Be-

[6] Matthew, W. D. Bull. Amer. Mus. Nat. Hist., **50**: 138–146. 1924.

cause of the obliterated contact between the bulla and the basioccipital and basisphenoid the elements forming the canal cannot be certainly determined but the position of the canal opening on the bulla suggests that it was probably entirely within the bulla. The small condylar or hypoglossal foramen is situated close to the postero-median margin of the large foramen lacerum posterius. In this respect its position is similar to that in *Martes* and some of the other genera of mustelids. In specimens of *Mephitis* examined the condylar foramen is much closer to the condyles. The stylomastoid foramen is partially obscured in the deep cleft between the bulla and the ridge connecting the paroccipital and mastoid processes. In the case of the postglenoid foramen a somewhat anomalous condition exists in which the postglenoid or temporal canal opens in two positions on both sides. In one position the opening is approximately as in *Lutra*, *Taxidea*, and *Gula*, antero-ventral to

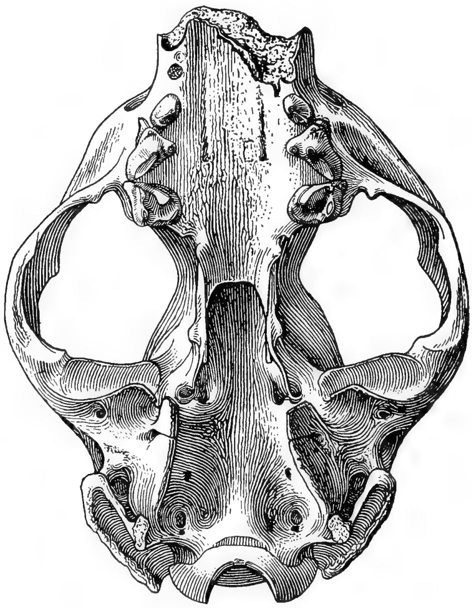

Fig. 3.—*Craterogale simus*, n. gen. and sp. Skull, type specimen, U.S.N.M. no. 13801, ventral view, natural size. Upper Miocene or lower Pliocene, Dawes County, Nebraska. Drawing by Sydney Prentice.

the audital tube, but is very close to the postglenoid process. In the second position, antero-dorsal to the audital tube and along the posterior wall of the zygomatic process of the squamosal, the opening is similar to that in *Mephitis.* The two openings though widely separate at the surface presumably join beneath the included segment of the audital tube which has fused to the squamosal. A similar condition was observed in a recent skull of *Taxidea taxus*.

Description of teeth.—The type of *Craterogale simus* exhibits the 3rd and 4th upper premolars and the 1st molar on both sides, and alveoli for the canine and 2nd premolar. In all probability the completed formula was as follows: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{1}{2}$. The combination of cheek teeth is common among mustelids, occurring typically in such genera as *Mustela, Mephitis, Spilogale,* and *Taxidea.*

The teeth, though sturdy, are small considering the muscular development indicated for the lower jaw. P^2, as shown by the alveoli, was two rooted, with the anterior root small and placed inward from the canine alveolus. P^3 is simple, without accessory cusps or styles, and exhibits a slight cingulum around the medial and posterior margin of the tooth. This tooth is separated by a short diastema from the posterior alveolus of P^2.

The carnassial is moderately low crowned and in occlusal view is nearly triangular in outline. The shearing blade is relatively broad transversely, and blunt, although the bluntness may be largely due to wear. The deuterocone (or protocone) is a distinct conical cusp placed well forward at the antero-lingual angle of the tooth, much as in *Martes* and *Mustela*, farther forward than in *Mephitis*. The lingual margin of the tooth posterior to the deuterocone is almost a straight line, with no appreciable indentation to set off the deuterocone such as observed in *Martes*. This inner portion of the tooth is without talon or tetartocone, but exhibits a weak cingulum for a short distance posterior to the deuterocone. The anterior margin of the tooth, extending from the deuterocone to a weak parastyle at the antero-external angle of the tooth, is only slightly indented, much less so than in *Martes* or *Mustela*. On this portion of the tooth margin the cingulum is conspicuous, and continues around on the outer surface, becoming weaker posteriorly.

The molar tooth is relatively large, with the outer portion distinctly long anteroposteriorly and the summits of the paracone and metacone well spaced. The portion of the tooth extending outward from the ridge connecting the paracone and metacone projects prominently forward and outward from the paracone, forming a conspicuous style at the antero-buccal angle of the tooth. The lingual portion of the tooth is well developed, but the heel is not so markedly expanded as in *Lutra*, *Taxidea*, or *Conepatus*, though almost as much as in *Mephitis*. The fossil molar, however, does not show the median anteroposterior constriction seen in *Mephitis* and many other mustelids. The protocone is prominent and rather centrally placed as compared with *Mephitis* and *Lutra*. It may be noted that the antero-ventral surface of the ridge connecting the protocone to the paracone is considerably worn. The hypocone is moderately developed but is not expanded so prominently as in *Mephitis* and *Lutra*. A moderate cingulum extends forward from the hypocone, around the antero-lingual side of the protocone, but its development is not comparable to that in *Martes* and *Mustela*. The ridge extending buccally from the posterior extremity of the hypocone is also noticeably worn, presumably through occlusion with M_2.

Comparisons with fossil forms.—Of the comparisons which may be made with other fossil mustelids, that with *Leptarctus* is among the most pertinent. *Craterogale simus* shows a striking resemblance in skull structure to *Leptarctus primus*, as illustrated by Matthew,[7] but exhibits a distinctly different type of dentition. Points of similarity between the two are seen in the short and broad skull, deep and widely expanded zygomae, prominent postorbital processes, separate and rugged temporal ridges, heavy lambdoidal crests, short basicranial region with large bullae which are markedly fused with the postglenoid processes, very short audital tube, and in the absence of P^1 and M^2. No detailed comparisons with the bullae can be made since these elements are incomplete in the *Leptarctus* skull. *Craterogale simus* differs from *Leptarctus primus* in a narrower postorbital constriction, less widely sepa-

[7] MATTHEW, W. D. Bull. Amer. Mus. Nat. Hist., **50**: 138–146, fig. 37, 1924.

rated temporal ridges (perhaps a matter of age), a less convex profile anteroposteriorly along the temporal ridges and dorsoventrally along the lambdoidal crests, P^4 without tetartocone (hypocone), and M^1 shorter and relatively wider transversely. The dental structure in *Craterogale* is more nearly that of a typical mustelid, whereas that in *Leptarctus* makes a closer approach to certain of the Melinae.

Among the other mustelids known from the Snake Creek beds, *Mionictis* makes the nearest approach to the type of lower dentition presumed for *Craterogale*, and comparisons between the two forms are not entirely satisfactory. The species of *Mionictis* are of relatively small size, though actually larger than *Craterogale simus*. The premolars are three in number and do not have accessory cuspules, but the premolar series is relatively longer and the premolars relatively larger and more elongate than would be expected in *C. simus*. The lower carnassial in species of *Mionictis* has a large talonid, as seems evident for *C. simus*, but the length of this tooth in the smallest of the two forms, *Mionictis elegans*, is 11 mm. The length of this tooth in *C. simus* apparently could not have been greater than about 9 1/2 mm and was probably about 8 1/2 mm.

Plionictis is one of the better known upper Miocene mustelids, having as its type *P. ogygia*[8] which is represented by both skull and mandible. The skull of *Craterogale simus* is quite unlike that of *Plionictis ogygia* in the development of the zygomae, and in having rugged temporal ridges. Moreover, the upper molar in the *Plionictis* skull is much shortened anteroposteriorly. This and other characters in both upper and lower dentitions of *Plionictis* are modifications in the direction of *Mustela*.

Craterogale is distinct from *Brachypsalis* in having a more reduced dentition. The maxillary portions referred by Matthew to species of *Brachypsalis* show alveoli for a second molar, and the upper carnassials and molars in these specimens belong to much larger species than *C. simus*. The upper carnassials in the species referred to *Brachypsalis* are illustrated[9] as having more medially extended deuterocones, and the first upper molars show a less prominent antero-buccal angle, a stronger hypocone, and a more outstanding cingulum antero-medial to the protocone.

The species of *Sthenictis* are characterized by a less reduced lower premolar series as are species of *Martes*, unlike the shortened type of jaw which is evident for *Craterogale*. The lower carnassial in *Sthenictis bellus* and *S. dolichops* from the Sheep Creek and lower Snake Creek horizons respectively, and in the similar *Cernictis hesperus*[10] from the Pliocene of California, has a relatively smaller talonid than is indicated for *Craterogale*.

Plesictis[11] from the Oligocene of Europe exhibits marked temporal ridges, and the upper carnassial, though relatively longer, resembles that in *Craterogale*. However, the skull of *Plesictis* is more elongate, has weaker zygomae, four instead of three premolars, and the bullae, though inflated, do not project ventrally as in *Craterogale*. M^1 in *Plesictis genettoides* is relatively short and transversely wider, with a somewhat less expanded heel than in *Craterogale*.

Remarks.—The relationships of *Craterogale simus* are obscure, due largely

[8] Matthew, W. D. Mem. Amer. Mus. Nat. Hist. **1** (7): 383–384, figs. 8–9, 1901.
[9] Matthew, W. D. Ibid., pp. 131–134, figs. 29–33, 1924.
[10] Hall, E. R. Jour. Mammalogy **16**: 137–138. 1935.
[11] See H. Helbing, Abh. schweiz. palaeont. gesells. **50**: 1–21, pls. 1–4, 1930; and J. Viret, Ann. Univ. Lyon, n. s. fasc. **47**: 166–183, pl. 15: pl. 16, figs. 1–2; pl. 30, figs. 1–4, 1929.

to the incomplete nature of so much of the fossil mustelid material which has been described from North America. It is possible that *Craterogale* is related to *Mionictis*, but this can not be demonstrated from the known material. On the other hand the structural similarity between this skull and that of *Leptarctus* as far as known seems more than mere coincidence, although the teeth are very distinct. However, the differences between the dentitions may not be much greater than between some mustelid genera which have been referred to the same subfamily, such as between *Meles, Helictus, Arctonyx,* and *Taxidea,* or as between *Lutra, Latax,* and *Enhydriodon.*

The skull characters exhibited by *Craterogale,* which possesses a truly mustelid dentition, furnish additional evidence for mustelid affinities of *Leptarctus.* Moreover, the cranial characters of *Leptarctus,* as described and figured by Matthew, seem to warrant recognition of a separate subfamily, the Leptarctinae, to which *Craterogale simus* may be referred tentatively.

MEASUREMENTS (IN MILLIMETERS) OF SKULL OF CRATEROGALE SIMUS

Length from anterior margin of nasals to occipital condyles	79.2
Length of nasals	17.3
Distance from anterior margin of nasals to line between postorbital processes of frontals	27.3
Distance from postorbital processes to posterior margins of lambdoidal crests	49.6
Width between orbits	21.8
Width at postorbital constriction	15.5
Width across zygomatic arches	61.0
Greatest depth of zygomatic arch	13.8
Width across mastoid processes	41.2
Width across occipital condyles	19.4
Depth from temporal crests to ventral extremities of bullae	41.3
Distance from posterior margin of palate to foramen magnum	38.0
Width of palate between molars	14.3
Length of cheek tooth series, P^2–M^1	24[a]
P^3, anteroposterior diameter	5.0
P^3, transverse diameter	3.0
P^4, anteroposterior diameter parallel to outer wall	7.7
P^4, greatest length over deuterocone	8.7
P^4, transverse diameter perpendicular to outer wall	5.6
M^1, anteroposterior diameter perpendicular to anterior margin	5.8
M^1, greatest diameter	9.6
M^1, transverse diameter perpendicular to outer margin	7.2

[a] Approximate

BOTANY.—*Three new grasses from Mexico and Chile.*[1] JASON R. SWALLEN, Bureau of Plant Industry.

Among the grasses in a recent collection of plants made by Francis W. Pennell in Mexico, were two new species of *Muhlenbergia.* One of these was found in the Sierra Gazachic, 35 kms. southwest of Minaca, Chihuahua, and the other in the Sierra Madre Occidental, near El Salto, Durango. The third species here described was collected at Cajon de los Pelambres, Dept. Illapel, Chile, by G. Looser.

[1] Received February 14, 1936.

Muhlenbergia lucida Swallen, sp. nov.

Perennis; culmi caespitosi, erecti, 60 cm alti, pubescentes; vaginae puberulae vel scaberulae, internodiis longiores; ligula obtusa, 3–6 mm longa; laminae 15–30 cm longae (superiores 2–5 cm longae), involutae, flexuosae, puberulae vel scaberulae; panicula 15 cm longa, ramis filiformibus, flexuosis, implicatis, basi nudis; pedicelli 10–15 mm longi, filiformes, flexuosi; glumae 3 mm longae, obtusae, hyalinae, pilosae; lemma dense villosum, 4 mm longum, bifidum; arista 12 mm longa, obscure geniculata, basi tortilis; palea villosa lemma aequans.

Perennial; culms caespitose, erect, 60 cm tall, appressed-pubescent; sheaths longer than the internodes, minutely scabrous or appressed-pubescent, sometimes nearly glabrous; ligule firm, obtuse, 3 to 6 mm long; blades 15 to 30 cm long (the uppermost 2 to 5 cm long extending beyond the base of the panicle), flexuous, firm, involute, minutely pubescent or scabrous; panicle 15 cm long, the branches scabrous or pubescent, filiform, flexuous, implicate, naked at the base, the lowermost 5 to 6 cm long; spikelets distant, the pedicels filiform, flexuous mostly 10 to 15 mm long, gradually enlarged upward toward the summit; glumes equal, 3 mm long, obtuse, hyaline, pilose, nerveless; lemma densely villous, 4 mm long, bifid, the teeth 1 mm long, subacute, the midnerve prominent, red, extending from between the teeth into an awn 12 mm long, more or less geniculate, twisted below the bend; palea equal to the lemma, hyaline, villous.

Type in the U. S. National Herbarium no. 1614380 collected on ledges of igneous rock, "Barranca Colorad," Sierra Gazachic, alt. 2300–2500 m, 35 km. southwest of Minaca, Chihuahua, Mexico, September 16–17, 1934, by Francis W. Pennell (no. 18955).

Muhlenbergia lucida is probably most closely related to *M. argentea* Vasey, the only other perennial species which has bilobed lemmas. There are several well marked differences, however, which easily distinguish the latter, the most conspicuous being the narrow panicles with appressed or ascending branches, the short pedicled, appressed spikelets, and the nearly glabrous lemmas.

Muhlenbergia subaristata Swallen, sp. nov.

Perennis; culmi dense caespitosi, erecti, 120 cm alti, glabri vel minute pubescentes; vaginae internodiis longiores, scabrae; ligula truncata, 1–2 mm longa; laminae 15–30 cm longae, 1–3 mm latae, involutae vel planae, attenuatae, flexuosae, scabrae; panicula 25 cm longa, ramis adscendentibus basi nudis, usque ad 10 cm longis; pedicelli filiformes, flexuosi, 1–5 mm longi; glumae 1–1.3 mm longae, obovatae, obtusae, erosae, scabrae vel pubescentes; lemma 4–4.5 mm longum, scabrum vel pubescens, muticum vel arista usque ad 2 mm longa praeditum; palea acuta, lemmate paulo longior, scabra vel pubescens.

Perrenial; culms caespitose, erect, 120 cm tall, glabrous or minutely pubescent; sheaths rounded on the back, overlapping, or rarely a little shorter than the internodes, scabrous; ligule truncate, 1–2 mm long; blades loosely involute, becoming flat with age, flexuous, 15–30 cm long, 1–3 mm wide, attenuate to a fine point, scabrous; panicle narrowly pyramidal, 25 cm long, the compound branches, rather distant, ascending, naked at the base, the lowermost 10 cm long; pedicels filiform, flexuous, 1–5 mm long, densely

pubescent below the spikelets; glumes 1–1.3 mm long, obovate, obtuse, erose, scabrous, pubescent at the tip; lemma 4–4.5 mm long, purple, scabrous or pubescent, awnless or with an awn as much as 2 mm long; palea acute, equaling or slightly exceeding the lemma, scabrous or pubescent.

Type in the U. S. National Herbarium no. 18572 collected along river, above Arroyo de Agua, El Salto, Sierra Madre Occidental, alt. 2600–2650 m, Durango, Mexico, September 1, 1934, by Francis W. Pennell (no. 18572).

This species of *Muhlenbergia* belongs in the group with *M. capillaris* (Lam.) Trin., *M. rigida* (H.B.K.) Kunth, and *M. reverchoni* Vasey & Scribn., but differs from all in the short, usually obovate glumes, and from the first two in the awnless or short awned lemmas

Festuca panda Swallen, sp. nov.

Perennis; culmi dense caespitosi, 15–40 cm alti, nodo unico geniculati, glabri; folia basi aggregata; vaginae rubrae, glabrae, membranaceae; ligula ciliata 0.3–0.5 mm longa; laminae foliorum basalium firma, arcuatae, 2–5 cm longae, infra glabrae supra scabrae; lamina folii culmi 1 cm longa appressa; panicula 3–7 cm longa, ramis brevibus simplicibus appressis vel adscendentibus 1–3-spiculis; spiculae 8–10 mm longae, 4–5 florae, appressae; gluma prima acuta 1-nervia, 2.5–3 mm longa, glabra vel marginibus scaberula; gluma secunda obtusa, 3-nervia, glabra, marginibus scabris; lemma 6 mm longum, acutum, muticum, glabrum, marginibus scabris; palea acuta, lemma aequans, carinis scabris.

Perennial; culms densely caespitose, 15–40 cm tall, somewhat flexuous, usually geniculate at the single node, glabrous; innovations numerous; leaves crowded in a dense basal clump; sheaths reddish, glabrous, becoming membranaceous; ligule short-ciliate 0.2–0.5 mm long; basal blades distichous, firm, stiffly arcuate spreading, 2–5 cm long, glabrous on the lower surface, scabrous on the strongly nerved upper surface; culm blades one, 1 cm long, appressed; panicles 3–7 cm long, the short, simple branches appressed or ascending, bearing 1–3 spikelets; spikelets 8–10 mm long, 4–5 flowered, appressed; first glume acute, 1-nerved, 2.5–3 mm long, glabrous, or sparsely scabrous on the margins, the second obtuse, 3-nerved, glabrous, scabrous toward the tip and on the margins; lemmas 6 mm long, acute, awnless, scabrous on the tip and margins, otherwise glabrous or nearly so; palea acute, about equaling the lemma, scabrous on the keels.

Type in the U. S. National Herbarium, no. 1614378 collected at Cajon de los Pelambres, alt. 2900 m, Dept. Illapel, Chile, January 1932, by G. Looser (no. 2151).

The geniculate single noded culms with one short appressed culm blade are characteristic.

BOTANY.—Gilmania, *a new name for* Phyllogonum, *a very rare genus of plants from Death Valley, California, apparently in process of extinction.*[1] FREDERICK V. COVILLE, Bureau of Plant Industry.

My attention has been called by Mr. C. V. Morton to the existence of a genus of mosses named *Phyllogonium*, older than the very rare

[1] Received March 14, 1936.

genus of flowering plants from Death Valley, California, named by me in 1893 *Phyllogonum*. Since the latter name therefore is not valid, I propose in place of it a new genus name, as follows:

Gilmania

Phyllogonum Coville, Contr. U. S. Nat. Herb. **4**: 190. *pl. 21*. 1893. Not *Phyllogonium* Brid. Bryol. Univ. **2**: 671. 1827.

The genus is now renamed in honor of Mr. M. French Gilman, of Banning, California, ornithologist and botanist, who has devoted years of observation and study to the flora of Death Valley and whose intelligent and persistent search for this seemingly lost plant has resulted in its rediscovery.

The original description of the genus is reprinted as follows:

Polygonacearum genus Eriogoneis affine. Nodi foliis tribus herbaceis petiolatis instructi. Flores lutei, pedicellati, ad nodos fasciculati, sine involucro sine bractea, facie in axilla folii, inserti, fasciculis superis brevitate internodorum adjacentibus, demum confluentibus.—Planta annua, prostrata, divergente ramosa, omnino luteola, ramis e nodo singulo tribus aut quinque, inaequalibus.

Nomen genericum e *φύλλαν* et *γόνυ* derivatum est, nodi enim folia tria plene expansa, nec ut plerumque in generibus propinquis bracteis reducta, gerunt.

The genus has but one species, which is given a binomial name as follows:

Gilmania luteola

Phyllogonum luteolum Coville, Contr. U. S. Nat. Herb. **4**: 190. *pl. 21*. 1893.

For an illustration and detailed description of the species and a discussion of the relationship of the genus to other genera of the family Polygonaceae, botanists are referred to the original publication.

The collections now available show that the plant when fully developed sometimes attains a diameter of more than 10 inches, the irregular rosette of stems lying flat on the ground. This habit and the yellow color of the stems and of the innumerable small flowers have suggested the common name goldcarpet. Even the leaves are yellowish. The specimens collected by Mr. Gilman show that when the plant reaches the fruiting stage the stems stand up from the ground, a position which undoubtedly facilitates the dispersal of the seeds.

The recorded history of *Gilmania* is as follows: On April 7, 1891, I found two specimens of an unknown plant in the lower part of Furnace Creek Canyon, Death Valley, California. They were growing in the dry gravelly wash of the canyon. No other specimens were seen. In the Botany of the Death Valley Expedition, published in 1893, these two specimens were made the basis of a new genus and species, *Phyllogonum luteolum*.

On May 18, 1915, Mr. S. B. Parish collected a few specimens of the plant

in Death Valley and in 1918, in *Notes on Some Southern California Plants*,[2] he said:

> Very sparingly scattered among the pebbles covering the dry bed of the stream [Furnace Creek], immediately above the small marsh [Furnace Creek Springs] from which the stream rises, probably the exact spot where Coville, on April 7, 1891, collected the two specimens on which he founded the genus, since which time the plant has not been rediscovered. Two small specimens were also seen in a dry wash between Furnace Creek and Saratoga Springs. So far as known, the species is an endemic of Death Valley, and very rare even there. The plants are prostrate, and the largest found [by Mr. Parish] had stems hardly 3 cm long.

In his book, *Death Valley*, published in 1930, W. A. Chalfant, on page 85, gives the following statement by Professor Willis L. Jepson, who collected plants in Death Valley in 1917:

> When on a long tramp down the Furnace Creek wash, my first trip down it, watching eagerly for the rare plants of the region, I saw a single individual of *Phyllogonum luteolum* about two inches high, a species known only from Death Valley. I took it and put it in my press, expecting to find enough of it, and went on down the wash. Within perhaps two hundred or two hundred and fifty yards I suddenly woke up to the fact that I was not finding any more, and so returned to the original spot, locating it with much difficulty. Whereupon I set up my plant press as a marker and carefully cast around the spot at an ever increasing distance for nearly an hour in the hope of finding other individuals, but failed. Nor did I on subsequent days find any more either there or elsewhere.

When I was again in Death Valley at the season for this evanescent annual, in April, 1931, and in April, 1932, accompanied on both journeys by Mr. M. French Gilman, we both searched very carefully for this plant, but found no trace of it, nor had Mr. Gilman been able to find it on previous journeys. He developed the theory that the few individual plants of this genus that had been collected in Furnace Creek wash had grown from occasional seeds that had been brought down the wash from some higher elevation which was the real home of the plant.

Mr. Gilman was again in Death Valley in 1934 and 1935. In 1934 he looked carefully for the plant but did not find it. In 1935 he renewed his search, and was rewarded by getting it in four different places, all within a few miles of the original locality.

The first plant of *Gilmania* found by Mr. Gilman, on April 14, 1935, was from the floor of Death Valley close to the foot of the mountains, two miles south of Furnace Creek Inn, a few rods south of the entrance to Golden Canyon, and about 100 feet below sea level. There were fourteen individual plants within a radius of 150 feet. Mr. Gilman afterward watched them carefully, but only three became large enough to flower and produce seed. The others dried up and died when they still had only a few leaves and no branches.

[2] Bot. Gaz. **65**: 336. 1918.

The next locality found by Mr. Gilman, on April 20, 1935, was near Artists Drive, a road in the mountains, entered from the bottom of the valley at a point about six miles south of Furnace Creek Inn. Most of the plants were at an elevation estimated at a little over 1,000 feet, along the crests and slopes of a "whitish hill formation" which "seemed rather highly chemical." Farther down Artists Drive, in a larger canyon leading out to the floor of the valley, Mr. Gilman found three well-developed plants at the edge of a sandy wash at about 400 feet elevation. Altogether, about forty plants were seen in the two localities along Artists Drive. Most of them were very small, and later died from lack of rain.

On April 27, 1935, Mr. Gilman, starting from Teck Springs, about half a mile northeast of Furnace Creek Springs, went north of east into some "low yellowish-white hills" and found there about thirty-five plants of *Gilmania*, five or six of them of mature size, the others very small. They were scattered over several of the small hills at an altitude of about 1,000 to 1,200 feet. Part of the drainage of this area goes into Furnace Creek, and these hills may well have been the source of the plants that have been found heretofore in the dry gravel of that stream bed by Parish, Jepson, and myself.

Samples of the soil in which Gilmania plants were growing, obtained by Mr. Gilman, were examined at the Rubidoux Laboratory, Riverside, California, through the courtesy of Mr. C. S. Scofield. Mr. Scofield has reported on these soils as follows:

The three soil samples were tested for total soluble salts by digesting for 24 hours, with shaking, in water, at the ratio of 1 part of soil to 5 parts of water. The solutions thus obtained were analyzed. Sample No. 1, taken near the mouth of Golden Canyon, contained 0.816 per cent of total salts, chiefly calcium sulphate. Sample No. 2, from a yellowish-white ridge on Artists Drive, contained 1.042 per cent of total salts, also chiefly calcium sulphate. Sample No. 3, from the edge of a sandy wash on Artists Drive, at the base of a bank of yellowish-white material, was less saline, containing only 0.167 per cent of salts, chiefly sodium bicarbonate and sodium sulphate. The boron content of all three samples, 0.44, 0.24, and 1.24 parts per million, was so low that this constituent is not to be considered as limiting plant growth in these soils. As compared with agricultural soils, the salinity of samples 1 and 2 would be regarded as high but not too high to prevent the growth of many species of plants. Sample No. 3 would be considered not saline.

These analyses do not disclose either the presence or the absence of substances that explain the occurrence of Gilmania on these areas.

The seeds of some of the desert annuals germinate so promptly when the ground is moistened that the young plants sometimes blossom and produce seed from a single good rain, before the ground has become dry enough to kill the plants. Occasionally one of these annuals, a *Cryptantha*, for example, produces seed when it is less than half an inch in height. From Mr. Gilman's observations in 1935 it is his tentative opinion that *Gilmania* can

not do this, but that at least two rains, properly timed, are necessary to enable the plant to produce seeds. In the season of 1935 the rainfall in the bottom of Death Valley was unusually heavy. The autumn and winter rains up to January 5, 1935, had totaled 0.89 inch. On January 5 there was a rainfall of 0.27 inch, on February 4, 0.72 inch, and on March 2, 0.09 inch. Mr. Gilman believes that a few seeds of *Gilmania* germinated after the rain of February 4 and that the rain in March carried these plants through to maturity. Some of the plants reached a diameter of more than 10 inches and produced an abundance of seeds. Most of the plants found by Mr. Gilman in 1935, however, were tiny, consisting of only a small basal rosette of leaves, and they died without producing either branches or flowers. These small plants, Mr. Gilman believes, grew from seeds that germinated after the rain of March 2 and dried up in the rainless period that followed.

From these observations we have a fairly clear view of the reason for the rarity with which flowering specimens of *Gilmania* appear, because good rains, suitably timed, are not common in Death Valley. For example, up to February 6, 1936, there had been only 0.21 inch of rain in the bottom of Death Valley since March 2, 1935. This total of less than a quarter of an inch in nearly a year was made up of 0.10 inch in May, and 0.11 inch in December.

Apparently *Gilmania* is a plant in process of extinction through the extreme dryness of Death Valley. Its seeds, like those of many desert annuals, evidently are able to lie dormant in the ground for several years. Some of them germinate after a good rain if the temperature conditions are suitable for germination, but these germinated seeds do not produce fruiting plants, apparently, unless the seedlings are boosted to a suitable size and vigor by a second rain, adequate in amount and properly timed. In most years any little *Gilmania* plants that have been able to start will die before they produce seeds, from lack of a second rain. The continued existence of this species apparently depends on the dormancy of a sufficient number of seeds to carry it over unfavorable years to years of adequate and properly timed double rains. If Death Valley becomes drier and drier, and years with suitable double rains become more and more infrequent, the vitality of the old *Gilmania* seeds in the soil will ultimately be insufficient to span these longer periods of years when no new seeds are produced, and extinction, which is now a menace, will become a fact.

BOTANY.—*Notes on the Myristicaceae of Amazonian Brazil, with descriptions of new species.*[1] I. ADOLPHO DUCKE, Jardim Botanico, Rio de Janeiro. (Communicated by E. P. KILLIP.)

During my botanical trips in Amazonia I assembled a good number of plants of that interesting but not sufficiently studied family,

[1] Received February 15, 1936.

Myristicaceae, which must be considered one of the most important elements of the hylaea-flora, principally in the western half of this immense plain. The types of the new species are preserved in the herbarium of the Jardim Botanico of Rio de Janeiro; cotypes have been distributed among the principal institutions of Europe and America. Of these last, special mention may be made of the U. S. National Herbarium in Washington. The material sent to that herbarium was compared with the Myristicaceae in the herbarium of the New York Botanical Garden by Dr. A. C. Smith, for which I thank him very kindly. Wood samples accompanied by herbarium material of several species have been deposited at the Yale School of Forestry.

A part of the material examined was gathered by me when I was in the service of the late Dr. J. Huber, the eminent botanist, Director of the Pará Museum (Museu Goeldi); duplicates of that material are deposited in the Jardim Botanico, Rio de Janeiro.

COMPSONEURA

COMPSONEURA DEBILIS (A. DC.) Warb. "Catinga" of Camanáos, Upper Rio Negro, State of Amazonas (*Ducke*, Herb. Jard. Bot. Rio 24445, distributed as a new species. This very small tree with pure white flowers is more like certain species of *Casearia* (Flacourtiaceae) than a Myristicacea. Adult leaves thick-coriaceous; ripe fruits orange-red; arilloid entire, purplish; seeds spotted, as in *C. sprucei* and *C. ulei.*

COMPSONEURA RACEMOSA Ducke. São Paulo de Olivença (Rio Solimões); observed once (male tree).

COMPSONEURA CAPITELLATA (A. DC.) Warb. To this species, described from Eastern Peru, probably should be referred a small tree of the upland forest of São Paulo de Olivença, a Brazilian village near the Peruvian frontier (Herb. Jard. Bot. Rio 19803 and 23693, male trees, and 19576, female tree with flowers and fruits). The fruits, ellipsoid or less frequently nearly globose are up to 5 cm long and 3 cm thick, though not yet mature. They are green, glabrous, with a longitudinal keel at one side; their hard, ligneous pericarp is 3 mm thick when dry; the seed is not yet developed. These fruits are surely glabrous, with a longitudinal keel at one side; their hard, ligneous pericarp is 3 mm thick when dry; the seed is not yet developed. These fruits are surely very different from those of all other known Myristicaceae.

COMPSONEURA ULEI Warb. This species must be placed, by its androecium, in the section *Coniostele* Warb.; its fruit resembles externally and internally that of *C. debilis* but is a little larger and of a pale yellow color, and its arilloid is white, instead of red as in all other Myristicaceae of which I have seen fruits. This very small tree, with long branches and yellowish

green flowers, is not very rare in the undergrowth of the upland forests of the Middle Amazon (western part of the State of Pará: Santarem, Lower and Middle Tapajoz, Obidos, Lower Trombetas; eastern half of the State of Amazonas: Maués, Manáos, Porto Velho; northwest of Matto Grosso: Santa Cruz of the Rio Jamary).

Osteophloeum

Osteophloeum platyspermum (A. DC.) Warb. One of the most frequent and widely distributed Myristicaceae of the upland rain forest of Amazonian Brazil, from the mouths of the Amazon and the neighborhood of the capital of Pará to São Paulo de Olivença, not far from the Peruvian frontiers. It furnishes here, for this family, the largest trees, these sometimes more than 40 meters high, but only in the thickest stems do we find a very thin red heartwood.

Iryanthera Warb.

The species of this very natural genus are more difficult to classify than those of *Virola*, being nearly as numerous but much more uniform in their characters. Indument is always scarce, the leaves and the adult fruits being glabrous; the structure of the androecium is less variable than in *Virola*. Probably the fruits furnish the best characters to establish a natural arrangement of the species, but unfortunately most of these are only known in the male form. This genus is apparently restricted to the Amazonian hylaea (including the Guianas and the northwestern part of the State of Maranhão), where it is represented by a rather considerable number of species, though much less abundant in individuals than is *Virola;* it is one of the most characteristic elements of the hylaea-flora. All the species grow in upland virgin forest, where they prefer the neighborhood of small streamlets. All are known by the vernacular name "ucuhúba-rana" (false ucuhúba), those which furnish wood of good quality also as "punán."

Iryanthera dialyandra Ducke n. sp. Speciei *I. ulei* Warb. primo adspectu valde similis, at foliorum basi anguste rotundata vel subcordata, inflorescentiis, saepius e ramulorum parte inferiore ad folia delapsa, elongatis, usque 70 mm longis; ab ipsa omnibusque aliis speciebus hucusque notis differt antheris 3 ad columnae apicem sessilibus e basi liberis divergentibus. Planta feminea ignota. Arbor parva, partibus vegetativis glabra; foliorum petiolus brevis vel ad 18 mm longus, lamina vulgo ad 22 cm rarius 27 cm longa et ad 7–9 rarius 11.5 cm lata, saepius subobovato-elliptica colore et nervatione ut in specie citata; inflorescentiae tenuiter ferrugineo-puberulae vix ramosae, rhachi robusta; flores virescentes, e nodulis (vel ramulis minimis) fasciculati, pedicellis 3–6 mm longis, perigonio basi bracteolato 1.5–3 mm longo in alabastro plus minus obovato, anthesi tripartito, androecei columna gracili quam antherae multo longiore.

Habitat circa Manáos silva non inundabili ad ripas paludosas rivulorum, locis Estrada da Raiz inter Cachoeirinha et rivum Mindú (Herb. Jard. Bot. Rio 19578) et Estrada do Aleixo (Herb. Jard. Bot. Rio 24446), mensibus julio et augusto florifera, leg. A. Ducke.

The free anthers give to this species an isolated position within the genus. Many species are similar in leaves and sometimes also in the form of the inflorescences, but their anthers are entirely connate with the column of the androecium.

IRYANTHERA ULEI Warb. (*I. macrophylla* Warb., male, not female.) *I. macrophylla* Warb. (1897) is a mixture of *Myristica macrophylla* Spruce ex Benth. (a plant which, according to the descriptions, would be remarkable by its very large leaves but which is known only in female herbarium material with anomalous fruits) and of *Schwacke* 595 (=3532), a male plant of which I examined herbarium specimens in the Museu Nacional of Rio de Janeiro. A cotype of *I. ulei* (Rio Juruá-Miry, Acre Territory, *Ule* 5724) corresponds exactly with Schwacke's plant, collected at Manáos. I found, near this city, a third individual evidently conspecific with both the last mentioned plants. It was a small upland forest tree, growing at the swampy margins of a streamlet near the Estrada do Aleixo (Herb. Jard. Bot. Rio 24456).

The leaves of *I. ulei* reach rarely 25 cm in length, their average size being only 20 cm; they are thick but very fragile. The inflorescences are remarkably short; the column of the androecium, though variable in length, always exceeds the length of the anthers.

This species may be mistaken for many others, as for instance *I. dialyanthera*, but the elongate inflorescences and the form of the androecium of the latter are distinctive.

Iryanthera polyneura Ducke, n. sp. Speciebus *I. ulei, dialyandra, longiflora, paraensis* et *lancifolia* affinis, ab omnibus differt foliorum costis secundariis utrinque 28–32, inflorescentiis masculis (solis notis) 15–25 mm longis, simplicibus, pedunculo (brevissimo vel ad 6 mm longo) et rhachi crassis, florum fasciculis multifloris in inflorescentia dense agglomeratis, dense rufo-velutinis. Arbor mediocris ramulis superne tenuiter cano-tomentellis, foliis adultis glabris petiolo 15–20 mm longo, lamina 20–29 cm longa et 6–11 cm lata, basi obtusa vel anguste rotundata, apice vulgo abrupte acute acuminata, basi et apice saepe complicata, crasse coriacea fragili, utrinque granulosa, costis secundariis supra impressis subtus prominentibus, ante marginem arcuato-conjunctis, venulis non conspicuis. Flores viridiferruginei, ante anthesin subglobosi vix ultra 1 mm diametro, anthesi profunde trilobi intus glabri, androecei columna brevi quam antherae (6, perfecte adnatae, breves) vix longiore.

Habitat silva non inundabili circa Fontebôa (Rio Solimões, civ. Amazonas), 4–9–1929 leg. A. Ducke (Herb. Jard. Bot. Rio 24454).

Very similar, at the first glance, to many other species with thick but very fragile leaves; it differs, however, from all others by the more numerous lateral ribs of the leaves. The very short and dense inflorescences may be anomalous; in *I. lancifolia* we find similar inflorescences beyond the more numerous inflorescences of elongate form which evidently represent the normal type. *I. ulei* Warb. has very short and dense male inflorescences, but its leaves have only 14 to 18 lateral ribs.

Iryanthera longiflora Ducke, n. sp. Speciei *I. ulei* partibus vegetativis simillima, solum ramulorum tomento diutius persistente. Inflorescentiae masculae (solae notae) in ramulorum parte inferiore infra folia numerosae, binae, 6–12 cm longae, sat flexuosae, super basin pauciramosae vel (praeter nodulos floriferos interdum longe pedunculatos) simplices, partibus omnibus tenuiter rufo-ferrugineo-puberulis, nodulis vel ramulis floriferis modice distantibus multifloris; flores brunnescenti-virides, pedicello 5–8 mm longo tenui, bracteola parva pilosa, perianthio ante anthesin obovato-oblongo ad 3 mm longo vix 2 mm lato, anthesi oblongo-ureolato vix ad 1/3 ab apice trilobo, intus glabro, androecei columna cylindrica tenui quam antherae perfecte adnatae multo longiore. Arbor mediocris ramulis crassis superne cano-tomentellis, foliorum glabrorum petiolo 1–2 cm longo, lamina 20–30 cm longa et 5.5–9.5 cm lata, oblongo-elliptica vel lanceolato-oblonga, basi obtusa vel acutiuscula, apice acuta vel brevissime acuminata, crasse coriacea fragili, siccitate supre fusca subtus rufo-ferruginea, supra parum subtus vix nitida, utrinque (subtus fortius) granulosa, costis secundariis utrinque 15–20, longe ante marginem arcuato-conjunctis, supra impressis subtus fortiter prominentibus, venulis non conspicuis.

Habitat silva terris altis secus flumen Purús inter Boca do Acre et Monteverde, civitate Amazonas, 10–3–1933 leg. A. Ducke (Herb. Jard Bot. Rio 24457).

The leaves are like those of *I. ulei*, but the inflorescences and their insertion, as well as the flowers, are very different. In comparison with the other species with large and thick but very fragile leaves, *I. polyneura* has the nervures of the leaves much more numerous and the inflorescences very short and dense; *I. dialyandra* has the anthers not connate, divergent; *I. paraensis* has very elongate and thin inflorescences and very small flowers; *I. lancifolia* has the nervures of the leaves very faint; and all these species have smaller and more or less globose flowers. Finally, in *I. densiflora* the flowers have a somewhat elongate form, but they are shorter than in the others and the inflorescences are simple and dense; the leaves of this species are, however, very different.

Iryanthera lancifolia Ducke, n. sp. Affinis speciebus aliis foliis magnis crassis coriaceis fragilibus fultis; differt ab *I. dialyandra* antheris 6 perfecte adnatis; ab *I. paraensis* inflorescentiis multum minus elongatis, robustioribus; ab *I. longiflora* inflorescentiis minus elongatis, non ramosis, floribus parvis; ab *I. ulei* inflorescentiis sat longis et floribus minoribus; ab *I. polyneura* costis secundariis foliorum multum minus numerosis et inflorescentiis sat longis; a speciebus citatis omnibus foliis magis lanceolatis costis secundariis in utraque pagina tenuissimis. Arbor 20–25 m alta, praeter innovationes glabra; foliorum petiolus 10–18 mm longus robustus canaliculatus, lamina 16–24 cm longa et 4–7 cm lata, saepissime oblongo-lanceolata vel lanceolata, basi obtusa vel subacuta, apice acuta vel breviter acuminata, crasse coriacea fragilis utrinque granulosa, supra fuscescens nitida, subtus ferruginescens subopaca, costa primaria valida subtus prominente, costis secundariis utrinque 14–18 supra tenuissime immersis subtus tenuissime prominulis. Inflorescentiae masculae fere omnes infra folia e ramuli parte vetustiore, binae, vulgo 3–7 cm longae rarius breves (abnormes?), simplices, nodulis floriferis vulgo sat approximatis, rhachi crassiuscula tenuiter puber-

ula; flores viridi-ferruginei, in nodulo plures fasciculati, cum pedicello (brevi vel usque 5 mm longo, tenui) et bracteola (parva) dense rufo-velutini, perianthio ante anthesin subgloboso vix ultra 1 mm in diametro, anthesi profunde trilobo intus glabro, androecei columna brevi quam antherae 6 parvae perfecte adnatae parum longiore. Arbor feminea ignota.

Habitat prope Manáos silva non inundabili inter Estrada da Raiz et Igarapé Mindú, 13–7–1932 leg. A. Ducke (Herb. Jard. Bot. Rio 24553).

IRYANTHERA PARAENSIS Huber (*I. elongata* Huber). Nos. 429 and 542, male and female, of Dr. Sandwith's British Guiana collection are not at all different from the plants of Brazilian Amazonia. This species is distributed in the hylaea from the vicinity of the Atlantic as far as the Upper Amazon (Fontebôa and Tonantins). Kuhlmann found it in northwestern Matto Grosso between Pimenta Bueno and Riozinho (Herb. Comm. Rondon 1974). It is distinguished from *I. hostmannii* by the frequently larger leaves, the very elongate thin and flexuous male inflorescences, the very small flowers, and a very short androecium column.

IRYANTHERA HOSTMANNII (Benth.) Warb. This species from the Guianas and the Upper Rio Negro of Venezuela has not been found in Brazil. I have seen a fruiting specimen in the Museu Nacional (Maroni, French Guiana, *Melinon* 1861, without number); its leaves correspond exactly with the drawing in Warburg's monograph, plate 4; one of its two fruits resembles the fruit of the same plate, but the other has an almost triquetrous form, reminding one of the fruit of *I. tricornis*.

IRYANTHERA DENSIFLORA Huber. Readily recognized by its simple and dense inflorescences with relatively large flowers. A tree of the very moist upland forest from the Amazon estuary (islands of Breves and Gurupá), the region of the railway between Belem do Pará and Bragança (Peixeboi), and the Middle Tapajoz (S. Luiz, at the foot of the lowest rapids).

Iryanthera coriacea Ducke, n. sp. Arbor parva, praeter innovationes tenuiter rufo-tomentellas glabra. Foliorum distichorum petiolus 12–17 mm longus robustus profunde canaliculatus; lamina 13–20 cm longa 4.5–7 cm lata, obovato-lanceolato-oblonga vel -elliptica, basi anguste rotundato-obtusa complicata, apice sensim vel subabrupte modice longe acuminata, crasse et firme coriacea, utrinque nitida, subtus aliquanto pallidior et granuloso-rugulosa, costa mediana utrinque prominente subtus basi crassa, costis lateralibus utrinque 15–18 ante marginem arcuato-anastomosantibus supra fortiter impressis subtus tenuiter prominulis vel subimpressiusculis, venulis reticulatis impressis supra bene conspicuis. Inflorescentiae masculae super petiolorum insertiones vulgo binae, usque ad 8 cm longae, simplices, substrictae vel arcuatae rarius subflexuosae, cum floribus tenuiter rufo-sericeae; flores e nodulis vel ramulis brevissimis fasciculati, in fasciculo vulgo plurimi, pedicellis 2–4 mm longis tenuibus, perianthio basi bracteola squamiformi munito, ante anthesin subtriquetro-ovato vel subgloboso diametro ad 1.5 mm, anthesi aperto 3 mm lato usque ad medium obtuse trilobo, intus glabro, androecei columna robusta superne dilatata, antheris 6 perfecte adnatis plus minus aequilonga. Planta feminea ignota.

Habitat circa Manáos loco Estrada do Aleixo silva humosa humida non inundabili, 16–5–1933 leg. A. Ducke (Herb. Jard. Bot. Rio 24451).

Remarkable by its thick and hard but resistant leaves (not fragile as those of *I. ulei, dialyandra, paraensis* etc.), with the lateral ribs deeply immersed on the upper side and weakly prominent beneath. The inflorescences are rather elongate, simple, with very small flowers.

Iryanthera elliptica Ducke, n. sp. Arbor 30-metralis trunco robusto cylindrico, praeter innovationes rufo-sericeas glabra. Foliorum petiolus 8–14 mm longus robustus canaliculatus; lamina 7.5–12.5 cm longa et 4–5.5 cm lata, plus minus elliptica rarius oblongo- vel obovato-elliptica, basi rotundata vel obtusa complicata, apice abrupte breviter vel modice longe acuminata, sat crasse et dure coriacea, utrinque nitidula, subtus granulosa et pallidior vel ferruginescens, costa mediana subtus mediocriter crassa, costis secundariis in utroque latere tenuissime impressis plus minus obsoletis, venulis inconspicuis. Inflorescentiae masculae praesertim in ramulorum parte vetustiore supra axillas foliorum jam delapsorum binae, usque ad 8 cm longae, vulgo parum vel modice flexuosae, sat dense rufo-sericeo-puberulae, simplices vel supra basin ramosae; flores flavido-virides e nodulis vel ramulis brevibus modice distantibus fasciculati, sat numerosi in fasciculo, pedicellis ad 3 mm longis tenuibus, bracteola dense rufo-pilosula, perianthio ante anthesin subtriquetro-obovato vix ad 1.5 mm longo demum profunde trilobo extus parce puberulo intus glabro, androecei columna cylindrica quam antherae 6 perfecte adnatae multo longiore. Planta feminea ignota.
Habitat prope Manáos in silvis terris altis ultra Flores, 1–7–1932, leg. A. Ducke (Herb. Jard. Bot. Rio 24450).

This species resembles at the first glance *I. sagotiana* but may be recognized by its coriaceous leaves, which are nearly as thick and as hard as those of *I. coriacea* (through a little more fragile) and are of elliptic form and very much smaller. It is distinguished from both by the much longer androecium column.

IRYANTHERA JURUENSIS Warb. I have in hand a great number of herbarium specimens, among them a cotype (*Ule* 5460). From these I cannot distinguish no. 7103 of the Herb. Amaz. Mus. Pará, which is the type of *I. grandiflora* Huber for the staminate flowers. Huber's species would seem to differ from *I. juruensis* chiefly by its longer flowers, but the same twig has numerous smaller (normal) flowers, which do not exceed the dimensions of true *I. juruensis*. The column of the androecium in this species is at least as long as the anthers; in this particular Huber's diagnosis of *I. grandiflora* is incorrect. The fruit is cylindric with rounded extremities, transversal in relation to the peduncle, and is slightly larger than that of *I. paraensis*. The species *I. juruensis* is spread through the upland forests of the Middle and Upper Amazon, from Santarem, Obidos, and the middle courses of Tapajoz and Trombetas to the Lower Japurá and the Upper Juruá (Acre Territory). Krukoff collected it at the headwaters of the Rio Machado (northwestern Matto Grosso). To this species belong nos. 8553 and 8749 of the Herb. Amaz. Mus. Pará (Faro and Serra de Parintins) and no. 23682 of the Herb.

Jard. Bot. Rio (Lower Madeira), all distributed under the name *I. sagotiana* by Huber and by myself.

Iryanthera grandis Ducke, n. sp. Arbor ultra 30 m alta, trunco cylindrico robusto, ligno interiore amplo rufo-brunneo bono, glabra, innovationibus rufo-tomentellis. Foliorum petiolus usque 2 cm longus supra canaliculatus, lamina 13–25 cm longa, 5–7.5 cm lata, obovato- vel rarius sublanceolato-oblonga, basi anguste rotundata vel breviter obtusa saepe complicata, rarius subcordata, apice brevissime et vulgo obtuse acuminata, adulta subcoriacea fragilis, supra nitidula, subtus subopaca et parum pallidior quam supra, costa mediana subtus crassa, costis lateralibus utrinque 16–20 ante marginem plus minus evanescentibus, subtus tenuiter prominulis, venulis nullis vel in utraque pagina tenuissime immersis. Inflorescentiae masculae super petiolorum insertiones saepius binae, vulgo 5–12 cm longae, rhachi apicem versus attenuata in vivis molli et flexuosa, tenuiter rufo-ferrugineo-puberula; flores circa apices nodulorum vel ramulorum brevium modice distantum fasciculati, cum pedicello (ad 2 mm longo, tenui) et bracteola (parva, sub ipso flore inserta) densius rufo-ferrugineo-sericei, perianthio intus glabro, in alabastro subtriangulari-globoso, anthesi aperto vix ultra 1 mm diametro late campanulato profunde tripartito, androecei columna brevissima infra angustata, antheris vulgo 6 albidis adnatis subaequali vel parum breviore. Inflorescentiae femineae fructiferae solae visae, e trunci nodis vix ultra 3 cm longae; fructus maturus breviter crasse stipitatus, circa 4 cm altus et crassus, circa 5 cm latus, demum in valvas duas semiglobosas dehiscens, pericarpio lignoso durissimo circa 1 cm crasso, glabro, arillodio purpureo integro, semine 3.5–4 cm lato et fere 2 cm alto et crasso, testa laxe sulcato-reticulata, albumine non ruminato.

Habitat circa lacum José-Assú prope Parintins (civ. Amazonas), silva non inundabili, arbor mascula, 15–9–1932 leg. A. Ducke cum ligno no. 151, (Herb. Jard. Bot. Rio 24447); in silvis collinis prope cataractas Mangabal medii fluminis Tapajoz (civ. Pará), arbor feminea fructifera, 10–12–1919 leg. Ducke (Herb. Jard. Bot. Rio 2896). "Ucuhúba-rana" vel "punán" appellatur.

This species is allied to *I. tricornis* Ducke, which furnishes also a very valuable wood. The leaves, however, are much larger, glabrous, with more numerous lateral ribs; the male inflorescences are shorter and stouter, with less distant floriferous nodes; the fruit has a very different form, being remarkable for its size and its ligneous, exceedingly thick pericarp.

IRYANTHERA TRICORNIS Ducke, Tropical Woods No. 31, 11. 1932; Archiv. Jard. Bot. Rio **6**: 9. 1933. This species, the "punán" of the Solimões river (Fontebôa, S. Paulo de Olivença) is a tree 18 to 30 meters high, with cylindric stem which furnishes a highly esteemed reddish brown, afterwards dark brown heartwood. It grows in the humid upland forest. It can be recognized by the medium-sized obovate leaves, the thin and flexuous male inflorescences, and the three-horned fruits, the form of which is more exaggerated than that of the fruits of *I. hostmanni*.

IRYANTHERA SAGOTIANA (Benth.) Warb. A small or scarcely medium-sized tree, frequent in the upland forests from the environs of Belem do

Pará to Santa Izabel at the Bragança railway, but not yet observed elsewhere in Amazonia. Nos. 8553 and 8749 of the Herb. Amaz. Mus. Pará (from Faro and Serra de Parintins), as well as Herb. Jard. Bot. Rio 23682 (of the Lower Madeira), are evidently *I. juruensis* Warb. The present species seems to be limited to that part of the hylaea near the Atlantic.

IRYANTHERA LAEVIS Mgf. A tree of medium size, collected by myself in the upland forests in the State of Amazonas near Manáos (Herb. Jard. Bot. Rio 24459), Fontebôa (Herb. Jard. Bot. Rio 24458), and Parintins (Lake Uaicurapá, Herb. Jard. Bot. Rio 24455). This species was previously collected in Amazonian Peru by Tessmann (type) and by Killip and Smith. Our herbarium specimens were distributed as a new species, but Dr. Smith has established their identity with *I. laevis,* an insufficiently described species of which he has seen a typical specimen.

The leaves of *I. laevis* resemble in color and nearly also in texture those of *I. sagotiana,* but in many other characters this species is more like *I. juruensis,* from which it differs, however, by the very insignificant nervures of the leaves and by the ample male inflorescences. The flowers though variable in size, are among the largest in this genus. A very good character is the abundance of the pale lenticels, which are never completely absent on the young branchlets and sometimes are present even on the rachis of the inflorescences; I never observed them in any other species of this genus.

Iryanthera obovata Ducke, n. sp. Arbor mediocris, partibus vegetativis praeter innovationes tenuiter puberulas omnino glabris. Foliorum petiolus 1–1.5 cm longus validus supra canaliculatus; lamina 8–11 cm longa et 3.5–6 cm lata, obovata vel oblongo-obovata, basi obtusa vel subacuta, apice vulgo late obtusa rarius rotundata vel brevissime obtuse acuminata, subelastice coriacea, margine subtus lineiformi saepe revoluto, concolor et vix nitidula (adulta subglauca), praesertim subtus dense granulosa, costa mediana utrinque prominente subtus basi crassa, costis lateralibus nullis vel supra tenuissime et obsolete impressis, venulis nullis. Inflorescentiae masculae (solae notae) super axillas foliorum (interdum delapsorum) binae vel solitariae, breves vel saepius usque ad 8 cm longae, simplices vel super basin pauciramosae, graciles, tenuiter ferrugineo-puberulae, florum fasciculis e ramulo brevissimo vel nodulo; flores in fasciculo bini vel pauci, virescentes, pedicellis 5–9 mm longis tenuissimis, perianthio basi bractea squamiformi breviter et longius pilosula, in alabastro subgloboso-ellipsoideo, anthesi circa 2.5 mm diametro, ad medium obtuse trilobo, extus appresse puberulo intus glabro, columna androecei e basi dilatata anguste cylindrica, antheris 6 omnino adnatis longiore.

Habitat in silvis "catinga" in regione Rio Negro superioris (civit. Amazonas) prope Camanáos (Herb. Jard. Bot. Rio 24452) et circa affluentem Curicuriary (Herb. Jard. Bot. Rio 24462), Octobre florens, leg. A. Ducke.

The present species can be recognized by its obovate and coriaceous leaves, nearly destitute of nervures, and by its rather elongate but few dense inflorescences with long and very thin pedicels. It resembles, at first glance, *Osteophloeum platyspermum,* but the leaves are shorter, more coriaceous, and

without nerves, and the inflorescences are different; these, in our new species, resemble a little the inflorescences of *Compsoneura ulei.*

IRYANTHERA PARADOXA (Schwacke) Warb. This species seems to have been found only once (*Schwacke* 3736 = 575, Museu Nacional Rio de Janeiro). It must be rare, because I have never observed it near Manáos, the type locality, where I collected no less than six of its congeners. It should be easily recognized from the diagnosis and illustrations in Warburg's monograph.

Obituary

ANDREW NELSON CAUDELL, entomologist of the Bureau of Entomology and Plant Quarantine and custodian of Orthoptera at the U. S. National Museum, died at his home, 605 Keefer Place, Washington, D.C., March 1, 1936. He was born August 18, 1872, at Indianapolis, Indiana. After receiving the Bachelor of Science degree at Oklahoma Agricultural and Mechanical College in 1897, and a year's study at Massachusetts Agricultural College, he joined the Bureau of Entomology of the U. S. Department of Agriculture in 1898.

Mr. Caudell's scientific work was concerned chiefly with the natural history and classification of the Orthoptera about which he wrote numerous papers, one of the last (unpublished) being in joint authorship on the Orthoptera of the District of Columbia and vicinity. His hobby was philately to which he also contributed important papers.

Mr. Caudell was a member of the American Association for the Advancement of Science, Association of Economic Entomologists, Entomological Society of Washington, Washington Academy of Sciences, and the American Philatelic Society.

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GENERAL SCIENCE.—*The new Aristotle.*[1] FREDERICK BARRY, Columbia University. (Communicated by C. E. CHAMBLISS.)

To those students of the history of science whose interests are—so to say—more scientific than historical, whose experience in the production of new knowledge has made particularly vivid the realization that discovery is far less frequently the result of happy accident than the consequence of systematically methodical investigation, and not so often the reward of mere industry as the fulfillment of theoretical anticipations—in a word, to ourselves, the most significant of all past scientific labors are those which have contributed either to the determination of effective ways and means in research or to the development of that conceptual representation of nature which enables us in some degree to understand the complicated interrelations of diverse phenomena, to organize our knowledge as it grows, and to discern the most promising pathways of further investigation.

It is common knowledge that we owe to the ancient Greeks, uniquely, not only the first inculcation of the scientific temper among thoughtful men and the first studies of nature that were exclusively guided by the disinterested spirit of free inquiry, but also the permanent establishment and extensive development of the basic principles of scientific method and the first theoretical correlations of positive knowledge. Among them the scientific habit of thought was born; and, during the eight hundred years that fate allowed for its vigorous development, was completely matured, both by introspective analyses of the natural processes of inference which yielded the principles of rigorous logical and mathematical procedure and by critical studies of the limitations of natural knowledge which yielded our characteristically pragmatic philosophy of suspended judgment.

On the other hand, the problems presented to the ancient theorists by natural phenomena commonly observed were sufficiently difficult to tax the acumen of their keenest and most subtle understanding.

[1] Address delivered before the ACADEMY, January 30, 1936. Received February 19, 1936.

The record of their scientific achievement, therefore, does not reveal much evidence of the investigation of those hidden regularities in natural processes that now interest us most; which, as we know, are revealed only by the experimental disentanglement of superimposed effects. Their theoretical physics was practically restricted to the mathematical representation of the most patent phenomena—those of geometrical configuration, apparent celestial movements, mechanical equilibria and the reflection and refraction of light,—and the rest of their natural philosophy remained in the condition of preliminary qualitative generalizations little more than descriptive. In comparison with the subtlety of their critical and methodical work, their theory, consequently, seems to us for the most part surprisingly simple and even naïve. We have so completely assimilated their mathematics, which remains the foundation of our own, that even when we remember its origin we forget that to them it was not at all a purely conceptual technique, but on the contrary a natural science; and since the rest of their physical theory, based on a necessarily meagre knowledge, has now become largely obsolete, it is very easy for us, naïvely on our own part, to dismiss it from serious consideration with reference to the progressive development of science, by pronouncing it wrong rather than incomplete. If, nevertheless, curiosity leads us to examine somewhat critically the content of ancient theory, it is not long before we realize that its falsity is precisely like that of all later scientific representations of nature that have been successively invalidated by the growth of knowledge; that the suggestive conceptions it embodied have assisted rather than impeded the development of later theory, and that they have been by no means so frequently discarded as progressively modified in conformity with the advance of knowledge,—in other words, that, contrary to first impressions, ancient theory was incomplete rather than wrong.

That such is the case is clearly due to the methodical predilection of the Greek natural philosophers. Their original motivation was pure curiosity: they desired, as Aristotle said, to know; not like their predecessors to seek security and advantage by magical participation in the mysterious potencies that seemed to control an external world more feared than loved, nor to find the satisfaction of desire and longing in poetical and religious imaginings of its nature, but in accordance with their cheerfully confident and rational predisposition to discover its immanent reasonableness, which they never doubted, and to depend on that. For men of this temper it was nothing more than obedience to the dictates of common sense to turn, when baffled in their

first attempts to discover this reasonableness by simple unguided observation of the confused and restless world about them, to the more careful study of ways of knowing. Nothing more strikingly illustrates their acuteness than that, having once confirmed their instinctive expectation by the discovery of certain regularities of interrelation among natural configurations and recurrent processes, they devoted their later efforts primarily to the problems of understanding; for they appear to have appreciated even then, as clearly if not as vividly as we do ourselves, that valid theoretical knowledge depends unconditionally upon the practise of sound method, and therefore that the determination of effective and dependable procedures alike in research and in conceptual correlation are necessarily prior to the productive investigation of phenomena in detail.

These philosophers thus became the pathfinders of natural science; blazed the passable trials that penetrated her rough domain, cleared them, and erected upon the secure foundations thus discovered the first watchtowers from which that domain could be surveyed, or, as they themselves expressed it, could be *theorized.* This was their great achievement; and the work was so well done—with a discriminating care so cautious that often our superficial critics even blame them for it—that though we have since widened and extended the ways they chose and rebuilt their theoretical structures, we have, after centuries of further exploration, neither abandoned those ways nor disturbed the foundations that they laid.

The most productive and influential of all these ancient methodical theorists was Aristotle, whom our ancestors for centuries venerated as The Philosopher, and whom we as well must still accord, I think, this uniquely distinctive title. It is probable that no individual thinker has ever so stimulated and developed the critical thought of other men. His conceptions have become a part of our intellectual heritage and, variously interpreted, affect profoundly—whether or not we are conscious of the fact—not only the character of our unconsidered preconceptions, but in considerable degree the philosophic temper which determines the criteria of our reasoned judgments. This circumstance makes unusually important all studies which yield us clearer insight into the original meaning of his philosophy, accentuating their historical value which is great on its own account.

I wish this evening to discuss,—not of course at all thoroughly but, if I can, suggestively,—certain implications of one such study recently made which appears to me to be quite unusually significant, particu-

larly with reference to its scientific bearing. Accept these remarks, if you please, not as a critique—I make no pretence of scholarly competence in the matter—but rather as a brief commentary, of the nature of, let us say, a report such as an observer with scientific interests might be expected to submit on the findings of recent research in a field not his own. These findings will supply my text; the sermon, for better or for worse, must be an interpretation essentially personal, even though it develops only immediate inferences, more or less obvious and in probable accord with most well-considered opinion.

The work to which I refer is Werner Jaeger's admirable study, *Aristoteles*, which appeared a year or so ago and is now available in a very pleasantly readable translation. This book, there can be no doubt, must be read by everyone who is seriously interested in the larger and more important issues of the history of thought—and particularly, so I think, those of the history of scientific thought. For myself it had peculiar interest, since its thesis, convincingly supported by scholarly arguments based upon the results of protracted and minute research and coördinated by an unusually scrupulous constructive imagination, brought into clear definition the substance of suspicions I had long entertained but could not, for lack of sufficient historical and scholarly knowledge, justifiably express: namely, that the Aristotle with whom the professional philosophers have made us familiar was not, any more than the Aristotle of the scholastics, the veritable ancient thinker, but rather a legendary figure—the product of a persistent theological—or, if you prefer, a metaphysical—predilection in speculative thought, which, having its roots in our common background of Christian belief, has, as everybody knows, determined the motive and contributed largely to the substance of all systematic philosophy from Spinoza to Hegel, and provided the guiding undercurrent of its most influential dialectical criticism from Berkley to the present time.

This philosophical tendency has, throughout the modern period, predominated in our institutions of learning, and is, I think, quite properly, and not at all accidentally, called Academic; for its spirit and method, essentially unmodified by the successive invalidation of particular dogmas and unaffected by the scientific habit of thought which antagonizes it, remain essentially the same as those originally inculcated by Plato; and as common thought becomes progressively more critical, its doctrines acquire an increasingly vivid pre-Christian coloring, reverting more and more definitely to the abstract conceptual idealism of this first philosophical supernaturalist. I can now

do no more than suggest in this way, by reference to its derivation, the general character of that type of philosophical thought which until very recently has wholly prevailed among the learned, and through the control of higher education by conservative institutions in their development from monastery and cathedral to university has, by perpetuating and continuously fortifying the idealistic attitude and its doctrinal presuppositions among scholars, practically determined the point of view from which the philosophy of the past is almost universally interpreted and evaluated. It has required no conscious effort to accomplish this: our common religious feeling, our moral aspiration, our necessary belief in the real significance of human life itself, inevitably seeks and usually demands the sanction of a transcendent reality beyond ourselves and beyond the world we know to sustain our labors and to guide them. The idealistic philosophy responds to all such needs. Even its coldest intellectual formulation focuses attention on the eternal, the changeless, the universal; and in one manner or another conceives it necessarily as mind, which alone can be thought of as immaterial, and so incorruptible and abiding.

Plato separated such an ultimate reality from the perceptible world of change and turmoil and imagined it as prior, self-subsistent and dominated by an immanent Good; Aristotle conceived it as immaterial Form, of which the physical world was an embodiment, developing in successive stages through particular forms from the gross and transitory to the ethereal and eternal under the control of a divine Purpose. Is it to be wondered at that in Christian Europe the names of these great men, who at one time were master and student, should be associated in thought and interpreted with reference to those most abstract and general of all their ideas, which refer to the ultimate problem which not Christians alone, but earnest men of all peoples in all ages have considered the gravest and most profoundly significant? Is it to be wondered at that endless labor should have been expended in efforts to reconcile their explicit contradictions; that in the failure to effect this reconciliation, those rationalistic philosophers who, unlike the theologians, could not escape their dilemma through denial of the final adequacy of reason and acceptance of revelation in its place, should seek refuge in some new variant of the Platonic realism, evading the arguments by which Aristotle had invalidated it by arbitrarily rejecting the very premises of his contradictory theory of knowledge? And finally therefore, is it to be wondered at that, in the ensuing turmoil of dialectical disputations, the distinctive character

of his philosophy—which, after all, is based on common sense and with respect to its fundamental principles is as clearly understandable as one would expect an eminently logical naturalist to make it—has been somehow lost to common view?

Whether or not it is to be wondered at, such is the case. In a word, the traditional Aristotle is not the portrait of any possible philosopher. It is a composite photograph of a single man facing opposite ways. One figure, rather faintly outlined, is that of a man who studies the actual world, writes elaborate works about the earth and the stars, about the forms and habits of animals, their anatomy and physiology, about man and his society, his art and the history of his thought and institutions; who derives all knowledge from experience, identifies the real with the actual and constructs a hesitant theology inductively from a logical interpretation of the phenomena. The other, much more distinct, is a transcendentalist who perceives that all that is incorruptible and permanent in nature is immaterial, that the essence of reality is disembodied form, the particular manifestations of which change perpetually in a process of development toward the changeless and eternal under the direction of divine power immanent in the whole, who therefore conceives the universal to be prior to and determinative of the particular, and reasons accordingly, inferring by means of an irrefutable deductive logic which he designs and subtly elaborates for the purpose, the essential character of particular realities from necessary universal premises: his only significant divergence from the thought of his great master Plato being occasioned by a less penetrating insight which permits him still to indulge a youthful ardor in studying the imperfect and distorted images of sense impression, and—perhaps under the influence of a personal ambition to be original—to devise an empirical theory of knowledge, the inductive logic of which he never perfects for the simple reason that this is impossible.

For the sake of clearness I have sharpened the actual outlines of this contrast; as a graphic pattern, however, it is correct. Both men pictured are lovers and students of nature, and both are empiricists, though one is earnestly and emphatically so, clearly conscious of the full import of this theory of knowledge, while the other is either weakly self-deceived by early predisposition or guilty in some sense of sophistry. On the other hand, both identify the permanent and changeless in experience as the ultimate reality, and conceive it as immaterial; but to the one its immateriality is conceptual, to the other it is transcendental. In other words, both see that the elements of

all knowledge are general ideas, but to the one these universals are generated in human thought by the perception of similarities and differences among particular sensory impressions, to the other they are preëxistent and are only discovered in this way; to the one, consequently, they are derivative, to the other prior. In general, therefore, according to the one true knowledge is to be arrived at only through a carefully laborious inductive process checked at every stage by the criterion of consistency, while to the other this process is unnecessary beyond a certain point, since true knowledge finally arrives through immediate intuitive recognition of the preëxistent universal, and by the deductive elaboration of its implications.

I think that the fundamental contrast is most clearly illustrated by this last antithesis. The one Aristotle reasons on the basis of empirical postulates, deriving concepts of increasing generality from the study of particular phenomena, inductively,—*a posteriori;* the other reasons from transcendental postulates, discerning by direct intuition immediately the general ideas that are only indicated by the final process of induction, and deriving from them implications of increasing particularity, deductively—*a priori.* In the philosophy of one the transcendent metaphysics is a superstructure, in the other it is a foundation. The one calls his general theory—which we call the Metaphysics—First Philosophy, which is practically equivalent to what Herbert Spencer called First Principles; the other calls it Theology. The faint Aristotle is both temperamentally and methodically a scientist, the more vivid Aristotle is a dogmatic metaphysician.

It must not be supposed that either of these portraits is a misrepresentation: evidence enough can be found in Aristotle's treatises to make both of them plausible. Until the time—toward the end of the nineteenth century,—when the influence of scientific positivism began to make itself felt in the world of philosophical scholarship, the picture of Aristotle the metaphysician almost completely obscured the other. When Zeller wrote, however, and afterward, that of the scientist emerged more clearly. It remained, nevertheless, in the background; and excepting in the thought of investigating scholars, remains there still.

I think that we may account for this persistence of an old impression by ascribing it not only to the force of habit but to two other causes at least: first, to the fact that, even among philosophers other than idealists—probably among all of them excepting a few radical empiricists, pragmatists and sceptics—the basic purpose of philosophy, if it is to be distinguished from science, still remains the Quest

of the Absolute; second, to the fact that scientists, who among all men would be most likely to grasp the full import of Aristotle's theory of knowledge and reality, offer little or nothing to the discussion, for the adequate reason that usually they accept without question the traditional view of him, and as a natural consequence seldom read his works at all. This will be evident to anyone who glances at the earlier chapters of our typical summaries of the history of science.

Here one always finds some reference to the great Stagirite, for his historical importance cannot be ignored; but this reference is brief, and its usual implication is to this effect: that he was a subtle dialectical thinker who attempted on the basis of reasonable but arbitrary presuppositions to excogitate once and for all the ultimate nature of things, and succeeded in constructing a cosmology so impressive that it imposed itself like an incubus on the thought of men for nearly two thousand years, making impossible any significant progress of natural knowledge until its hold was broken by the destructive criticism of Bacon and the experimental investigations of Galileo; that this repressive influence was due to its perpetuation of old Greek representations of nature which were the final results of a succession of naïve hypotheses quite unsupported by experimental evidence, subtly elaborated by deductive reasonings *a priori*, and supported by dialectical arguments purely logical in the characteristic manner of the Greeks, whose scorn of vulgar labor inhibited their scientific development by restricting their thought to the domain of pure ratiocination; that Aristotle is to be credited with an effort to promote the study of nature and particularly that of animal life, but that, sharing these limitations and guided by an unusually intense desire and aptitude for synthetic conceptual generalization, he ultimately produced little more than a transcendental metaphysics, the only positive achievement involved in which was the development of formal logic; that this is sufficient to secure his fame, but that his philosophy as a whole cannot properly be called science at all, involving, as it does, conceptions of immanent potency, vital force and abstract notions of causality derived from the idea of a guiding mind and purpose in nature, and culminating, as it does, in a theology; and that, finally, his simply descriptive biology is vitalistic, his psychology animistic, his chemistry merely an empty occult theory of subsistent forms and qualities, and his physics, which at least is positive, arbitrarily dogmatic and wholly wrong, especially with reference to falling bodies.

Now, even this estimate cannot be said to be wholly unjust. It is

that which a scientist must in candor make, when, accepting as is reasonable the expositions and commentaries of the historians of philosophy, he evaluates the work of Aristotle from his own point of view. If, however, curiosity leads him to examine these presentations in his customary way, separating explicit statements of particular conceptions and doctrines from their argumentative context, comparing them with reference to their diverse implications, and thus inferring, without reference to past opinion, their common ground, he will then certainly begin to suspect that, false though Aristotle's picture of nature may be, there is the possibility that its falsity may not after all be that of a synthesis based on premises and guided by habits of reasoning fundamentally wrong, but rather that of a genuinely scientific theory of nature that has been invalidated by new knowledge, like Copernican astronomy or Cartesian mechanics, like the corpuscular and caloric theories of light and heat, or Stahl's phlogiston theory, or Lamarck's theory of evolution, or—dare I say—Bohr's theory of the atom; concerning all of which one may assert, as the curate at the Bishop's breakfast table said of the eggs served him, that parts of them are excellent.

If this suspicion engenders sufficient courage, he will then read the original treatises. This will be difficult, even in translation. The *Metaphysics,* to which he will have been invited first to turn, is not consistently sequential, and its form in detail is imperfect; the diction is very often turgid and elliptical, there are reiterations and cross-weavings of slightly variant arguments and criticisms which cannot be understood without further knowledge of the antecedent and contemporary philosophy; and often the parts cannot be made clear without a knowledge of the whole. Each in its own way, the other theoretical treatises offer like difficulties. The subtle elaboration of the *Analytics* is intolerable; the *Physics* is a mass of discussions wholly concerned with abstract generalizations. Throughout, the arguments by appeal to reason wholly predominate, and it is the logician who passes judgment, though the grammarian is always at his elbow appealing to common sense, and the observer contributes to the evidence adduced. Altogether, the first impression gained from this reading is such as to discourage the hope of finding here much of science as we know it, and to concede to the philosophers the reasonableness of their traditional evaluation. When the broad outlines of the system become clear, however, when the whole becomes in this sense known, the scientist whose presence we first suspected again emerges; but

still he is far from dominating the metaphysician, and it becomes even clearer why the traditional figure has always been composite and inconsistent.

But now, suddenly and convincingly, this age-long difficulty has been resolved: not by further rational analysis of the content of the treatises as they stand, but by an historical investigation which has at last presented to us clearly outlined, in place of the static sculptured figure of tradition, the picture of a living man; and in place of the conglomerate collection of his writings, which scholars heretofore have been forced to interpret all at once as if they were the product of a single mind, at least two groups of writings composed at different times and guided by the changing basic conceptions of a rapidly maturing critical thought.

This is the work of Jaeger. I cannot here and now, of course, stop to present his arguments: granting the facts he adduces, as we always must and do grant them in discussing the results of highly reputable scientific research, I shall only say that his inferences, based on a considerable mass of data both historical and literary, seem to me to involve a surprisingly slight and inconsequential amount of conjecture and to be wholly convincing—the more so since I can imagine no conclusions opposed to those he draws to be consistent with the historical evidence that refers to the thought and work of Aristotle's immediate disciples. In broadest outline, then, let us survey in the light of Jaeger's findings, the course of their master's intellectual development.

When as a youth of seventeen,—born of a family of physicians and bred under the influence of the naturalistic habit of thought which the Ionian medical schools had long inculcated among men of that profession—he left his father's home in Stagira and came to Athens, the Academy of Plato had already been solidly established as the stronghold of the most conservative philosophical tradition of Greece. It was not a centre of important scientific activity: indeed it had never been that. To the Ionian philosophy, the first science properly so-called—the first disinterested, objective, exclusively rational and freely critical investigation of nature, which had culminated in the atomic theory of Leucippus and Democritus and the physical astronomy of Anaxagoras—Plato, like his venerated teacher Socrates, remained completely indifferent. To the great sophists of the preceding generation, contemporaneous with Socrates, who had laid the foundations of that empirical and critical epistemology which later produced

the sceptical philosophy of suspended judgment that we now call scientific, he was sharply antagonistic. Their humanistic interest he shared, and his original motivations were wholly ethical and political; but his intentions were reactionary, and his earlier philosophical work was guided by the purpose of establishing a supernatural sanction for morals and an aristocratic state as the agency by which his teachings, thus supported, were to be imposed upon humanity. In Aristotle's time these motives had already found expression in the famous transcendental theory according to which the ultimate reality was an incorporeal world of subsistent Ideas apart from the world of appearances, perceptible phenomena being merely the distorted images of this reality and worthy of study only for the suggestions they conveyed to the imprisoned souls of men of the final Truth and eternally dominant Good which in their free immortal state these souls had known by immediate intuition.

The Academy, when Aristotle entered it, was no longer engaged in discussing the ethical and religious import of this theory, but was attempting the more difficult task of giving it clear conceptual definition. Discussion among the younger members of the school was eager, lively and doubtless keenly dialectical. It would not be a bad guess to ascribe the logical trend of Aristotle's later thought primarily to this stimulation. What else he gained from it can only be inferred from the content of Plato's later treatises. The first of these, the *Theaetetus*, shows clearly that its author had already found in the abstract concepts of mathematics a clue to the more subtle definition of the Ideas. Mathematics, then, was becoming increasingly important in the discipline of the school; but Academic interest in it was metaphysical, and appears to have contributed little or nothing of significance to its development. The great geometers of the time lived and worked elsewhere, as had their predecessors: Archytas at Tarentum in Italy, and Eudoxus of Cnidus, the outstanding scientific genius of the age, at Cyzicus. There Eudoxus had established a scientific school the activity of which profoundly influenced the Academy, who assimilated what they deemed important of its discoveries, just as they had assimilated those of the now dispersed Pythagoreans.

From certain refugees of this strange brotherhood, who had developed the first systematic mathematics out of their quasi-Orphic religious rites of purification, Socrates had already borrowed a not inconsiderable amount of mystical doctrine; and Plato, following him, was fascinated by it. His poetical temper, which responded so spontaneously to the elusive suggestions of ancient myth and legend, found

not only in these but also in the Pythagorean numerology a vague significance which appeared to him profound; and at this time, the new knowledge of Babylonian astralism which the widely-travelled Eudoxus had brought to Greece accentuated this wondering interest in things mysterious. Plato's later work in this manner became even more deeply tinged with mysticism, and toward the end verged strongly toward the occult. His theory of Ideas, originally the imaginative product of a moral aspiration, but now rationalized, excepting for its Orphic and Pythagorean content, as an idealistic representation of the world of ultimate reality, became more definitely religious. With its further syncretic development, Chaldean astrology appeared for the first time as an element in Greek speculative thought; the descriptive names of the planets were replaced by the names of those Hellenic deities which most closely resembled the Babylonian; Zoroastrian elements entered to accentuate its blending of morals with the worship of the heavens, and so on—until finally its metamorphosis into a system of dogmatic beliefs was complete. This stage of Plato's thought is best represented by the *Timaeus*, an indefinite and poetically suggestive work which scholars have struggled for centuries and still struggle to interpret rationally, and by the *Laws* in which, among many expressions of arbitrary intolerance, he condemns as atheistical and punishable by death all those who still venture to study astronomy otherwise than in his own manner as an orthodox religion.

The younger generation in Plato's school did not accept all this, and it seems that not a few of them were becoming destructively critical of certain tenets of his theory even at the time when he wrote the *Parmenides*, though all of them, probably, subscribed to his fundamental doctrine. Among these was Aristotle. He remained at the Academy for twenty years; wrote dialogues of literary excellence in the later didactic manner of his master, and meanwhile, though still under the compelling influence of Plato's personality, gradually developed his own ideas. But, so far as we know, he wrote nothing in contravention of the school's accepted teachings before Plato died. For three hundred years thereafter only his immediate followers knew his later treatises; for shortly after his own death these disappeared, and were rescued from oblivion only when Andronicus of Rhodes recovered them in the time of Cicero. Aristotle's ancient reputation, therefore, was that of a disciple of Plato; and his dialogues were accepted by the Neoplatonists themselves as pure Platonic doctrine.

When Plato died Aristotle left Athens, and lived for a few years in

association with his friend Hermias, the tyrant of Atarneus in Asian Aeolia, lecturing, either occasionally or regularly, in the school that had been founded at Assos under this ruler's protection. Then, having accepted an invitation from Philip of Macedonia to become his diplomatic adviser and the tutor of his son, the young Alexander, he spent another few years at the Macedonian court. These independent occupations, in part philosophical, in part political, occupied the next twelve years, which were the most productive of his life. It was during this time that he first formulated the principles of his own philosophy, and broke awayfrom the intellectual tradition of the Academy, giving up the opinions that formerly held him, gladly, as Plutarch says, because he considered this a necessary sacrifice to the truth.

The dialogues written during his last preceding years in Athens, though they lack completely the allusive indefiniteness and mystical obscurity of Plato's writings, emphasize a demand for exactitude in scientific thought and give expression to that love of nature which he seems never to have lost, still assert the primacy and sufficiency of a purely theoretical knowledge, such as is revealed only to the creative intellect that reflects upon immaterial being alone and which discovers thus and contemplates only what is perfect, changeless and eternal in nature; and they reiterate the belief that the human soul, immortal though imprisoned in the corruptible flesh, is part of this divinity, and advocate a rigorously ascetic code of morals which recognizes the utter worthlessness of earthly things.

Such is the tone of the Aristotle of the Academy as he is revealed to us in the extant fragments of his dialogues. That shown in a later short treatise entitled *On Philosophy*, which Jaeger assigns to his very earliest years at Assos, is strikingly different. In this work, which appears to be a statement written expressly to define his first departure from the Platonic doctrines, his whole mental attitude appears to be changed. The religious feeling remains; its object, however, is no longer the imperceptible world of eternal Forms, but the living world of nature. Cicero quotes from it the following eloquent passage:

> If there were men who had always lived beneath the earth in good and shining habitations, adorned with statues and pictures and supplied with all the things possessed in abundance by those who are considered happy, and if, however, they had never gone out above the earth, but had heard by rumour and report that there is a certain divine presence and power, and then if at some time the gorges of the earth were opened and they were able to escape out of those hidden places and to come forth into these regions which we inhabit, then, when they suddenly saw the earth and the seas and the sky, when they had learnt the greatness of the clouds and the power of the winds, when they had gazed on the sun and recognized his greatness

and beauty and the efficacy with which he causes day by spreading his light through the whole sky, when moreover, night having darkened the lands, they perceived the whole sky laid out and adorned with stars, and the variety of the lights of the moon, now waxing now waning, and the risings and settings of them all and their courses ratified and immutable to all eternity—when they saw this they would straightway think that there are gods and that these are the mighty works of gods.

Evidently enough, it was no ascetic transcendentalist who wrote these words. They are those of a man who is wholly alive, and alert to the beauty and wonder of the sensible world about him—the Ionian naturalist come to life again. Even his discussion of theory has this background: it is historical; successive philosophical ideas are presented, as well as may be chronologically, as phases of a continuous development; and the treatment of religion is the same. This natural history of thought—the first ever written—is followed by a destructive criticism of the theory of Ideas. Aristotle's original arguments are not preserved, but, being of necessity logical, are not improbably the same as those of the first book of the *Metaphysics*, which was written, according to Jaeger, at this time or very little later. These show that the Ideas are wholly gratuitous, that their existence would imply an infinite regress of like ideas-of-ideas, that whenever their nature is defined they become mutually inconsistent, that the notion of a *participation* of phenomena in the Ideas is meaningless, and that the latter, being changeless, offer no explanation whatever of the processes of nature; from all of which he concludes that they are mere words. It is the physical world itself, he says, which is eternal; a world of things in process of change, being continually generated and destroyed, but in definable ways which produce, disintegrate and reproduce, endlessly, the same forms out of an indefinite material substratum; forms which exhibit such similarities that they can be classified by types and groups of types increasingly inclusive but always definable by abstraction. It is this very corporeality, this endless series of recurring forms—shapes and lustres, densities, odors, viscosities, tones and colors, these specific potencies which always yield the same substances by like processes of growth and transmutation, and these sharply definable relations between bodies that are characterized by such attributes, which permit their grouping by classes in generic order—it is these elements of experience that constitute the eternal and changeless. For, whether they are masses, or potencies or qualities, or species and genera, and though their distribution perpetually changes, *as such* they are always the same, and occur in the same associations. They are incorporeal and universal, that is to say,

they are ideas; but they do not exist apart from the physical world; they are, on the contrary, in it and of it; and further, since this is so, they become known, not at all by some reminiscent illumination of the immortal soul, but by observation and study of the actual world, as general concepts which define its underlying structure and order.

This minimal amount of Aristotle's final First Principles may confidently be assigned to the period of his treatise *On Philosophy.* Whether or not it was further developed at this time does not matter; for the basic conceptions of his final philosophic doctrine are here presented. It is evident that together they signify, not a modification, revision and development of the ideas of Plato, but their unequivocal repudiation.

It is still contended, and with justice, that Aristotle's recognition that all knowledge is conceptual, the terms necessary in any reasoning whatever being abstract and general, is due to his training in the Academy, where all discussion concerned itself not ingenuously with the nature of things without reference to the process of knowing, but rather, introspectively and self-consciously, with ideas. But this was the character of all critical thought from the time of the sophists down. Aristotle himself acknowledged his debt to Socrates by saying that two things in fairness must be ascribed to him, inductive arguments (about the meanings of terms) and universal definition. The school of Plato had developed this analysis, and brought clearly to light the fact that general concepts, in contrast with the changing world to which they originally referred, were changeless forms of thought; but hypnotized by this idea just as the Pythagoreans before them had been hyponotized by the idea of changeless number, and the Eleatics by the idea of the Absolute, and infected with the mysticism of these older schools which Socrates had transmitted, they shared his complete indifference to natural philosophy, forgot that the changeless entities on which they meditated were ideas conceived by the human mind, sought no generating cause behind them and instead of developing a rational epistemology pronounced them absolute.

Without further reference to the vagaries of mystical thought to which this dogmatism led, it is easy to see why Aristotle rejected it. His spontaneous love of the world of nature, which animates the striking passage I have just quoted, forbade him to accept as valid any theory of reality which could not explain its incessant change, and which ignored the immanent power within it—the compulsion of

fact, which obviously determines both will and waking thought. In addition, his genetic habit of thinking, which may, perhaps, be traced to that particular interest in living nature which was the interest of his ancestors, compelled him tirelessly to seek out causes for everything, and to rest dissatisfied with any doctrine which left anything causeless save the totality of Being. He thus discovered the generating cause of the ideas in perceptions of the natural world, remembered, compared, discriminated, generalized and arranged in generic order; and thus outlined the first psychological epistemology, that which refers all knowledge to physical experience. This is made evident in the first paragraph of the *Metaphysics*, from which I shall presently quote. And finally, his treatment of the Ideas shows even more clearly that to his logical mind, the keenest that had yet appeared in the world, the Platonic conceptions were altogether too incoherent and by implication too absurd to be credible even as reasoned dogma. I must emphasize this point. Without reference to his own theory of the nature of things, and by logic so pure that even the purest rationalist could find no flaw in it, he utterly destroyed the Platonic theory. If its like survives today this can only be by grace of an act of faith.

In its place Aristotle erected a structure of general conceptions, explicitly derived from sensory experience of the physical world. I venture to say that no mutation in the whole history of philosophy—save that of its very origin in ancient Ionia—was so uncompromisingly abrupt and complete. What, now, was the final character of this new philosophy of nature? Already we have surveyed its basic conceptions. Time presses, and gives no opportunity for discussion of its subtle elaboration and of the arguments adduced to support it; but this is not necessary. Its elaboration is largely a minute analysis intended to make its postulates and the logical consistency of its derived conceptions unequivocally clear; its arguments are those presented to contemporary philosophers, principally Platonists, who are met usually on their own ground. The analysis is minute beyond all present necessity, the arguments are equally wearisome and their purport not infrequently obscure excepting to one fully versed in the conflict of opinion in Aristotle's own day. I wish, however, to call attention to certain points that would be of particular interest to a scientist whose curiosity might lead him to ask how far this ancient thinker advanced toward that view of the world, familiar to us, which is the actual outcome of the philosophical empiricism he sought to establish.

Everything essential to this inquiry will be found in the final text of

the *Metaphysics,*—which is a late compilation of lecture briefs and texts, in large part written at the time of his treatise *On Philosophy* but amended and amplified in his later years—and almost enough for the purpose will be found in its fourth book, called *Gamma.*

The very first words of this treatise state, simply, both its purpose and the predisposition of its author. "All men," says Aristotle, "by nature desire to know. An indication of this is the delight we take in our senses; for even apart from their usefulness they are loved for themselves. . . . By nature animals are born with the faculty of sensation, and from sensation memory is produced in some of them. . . . The animals other than men live by appearances and memories and have but little of connected experience. . . . But in men, from memory experience is produced; for many memories of the same thing produce finally the capacity for a single experience. . . . And art arises when from many notions gained by experience one universal judgment about a class of objects is produced."

This is the utterance of a man who not only wishes to know, but asks immediately how we know; and answers the question briefly by sketching the natural process of knowing in fewest words as if it were a matter commonly understood. There is not here—nor, indeed, elsewhere—any suggestion of the possibility of knowledge derived otherwise than by inductive inference from experience of the natural world. This world Aristotle recognizes as independent of and prior to the act of knowing, just as we do, and for the same reason,—namely, that it is a world of necessity in which compulsions constrain both will and thought; and he says further that "it is impossible that the substrata which cause sensation should not exist even apart from the sensation. For sensation," he says, "is surely not the sensation of itself; but there is something beyond the sensation which must be prior to it, since that which moves is prior to that which is moved. . . ." Not only, therefore, do we derive our knowledge from experience: the character of our knowledge is predetermined by natural necessity. Consequently, with respect to its sensory foundation at any rate, it is true knowledge: a direct reflection of fact. "For," he says, "it is not possible to be in error with respect to the question as to what a thing is save in a accidental sense," that is, by inconsistent identifications due to ignorance of attendant circumstances and consequently erratic inference, which further and more extensive observation will correct. Against the sceptics who emphasized the diversity of different individual sensory impressions of the same thing, and insisted that a choice between the conflicting ideas derived from such impressions

must be arbitrary, he argued that "the truth is not that what appears exists, but that what appears exists *for him to whom* it appears, and *when* and *in the sense in which* and *in the way in which* it appears." Here is an admission of the relativity of knowledge; but a denial of its indeterminacy, since its relativity is defined as the mutual interdependence of impressions. Know the whole *Gestalt,* and you know truly.

It is but a step from this position, in the direction of Aristotle's own genetic tendency of thought, to admit, in recognition of the incompleteness of our knowledge, the necessarily tentative character of all conceptual representations; but Aristotle will not go this far, for reasons that will appear. He knows, like everybody else, that we do possess a store of perfectly dependable knowledge derived from the correlation of diverse impressions which within human experience is final: in a word, that we know a multiplicity of undoubted facts, some of them of inclusive generality. He expressly postulates, therefore the possibility of a similar positive knowledge of everything, by asserting *a priori* the minimal necessary assumption, which is that a thing cannot be and not be in the same sense at the same time. This postulate, called the law of contradiction by logicians, might equally well be called, by one more interested in the theory of knowledge, the law of exclusive discrimination; for it is derived from the conviction that things can be unequivocally identified. He justifies it, conclusively enough, by the observation that to reason at all we must start with postulates of some sort, since otherwise our thought would be involved in an infinite regress of conceptions; and remarks that no postulate could be more simple than this one, which is, furthermore, consistent with all experience. He challenges the sceptics to dispute it, and promises to entangle them in hopeless confusion of thought if only they will say *something* and not take refuge in silence, expressing their doubt, as Cratylus was forced to do, by merely wiggling their fingers.

We are all familiar with the general outlines of the conceptual structure that he builds on this foundation: that of a finite corporeal world which is continuous—for there is something everywhere even if it is no more than warmth and cold or the movement of the aether which men call light—and yet heterogeneous, separated into parts distinguishable by different attributes. These distinguishable somethings (or, more briefly, things), which Aristotle calls *substances,* are generated and destroyed, come to be and pass away; but while they exist, there is that in each of them which, quite apart from those

accidental attributes that may occasionally and indiscriminately affect them, is always the same,—persists,—remains unchanged; which upon its regeneration reappears unchanged; which, indeed, continuously exists unchanged as its incorporeal *essence,* the object of pure conception.

There still attaches to the word essence—thanks to the persistent bad habit of many scholars who continue to think about Aristotle in Latin—a not inconsiderable flavor of the occult. It is worth while, therefore, to remark concerning this word (one among several in the translated Aristotelian vocabulary which are similarly affected) that the suggestion of transcendental mystery it conveys is quite gratuitous. This we realize at once when we say instead that this suggestion of mystery is not *essential.* There is nothing mystical about these essences: they are simply physical properties or, in Aristotelian terminology, *forms* which uniquely characterize different kinds of substances, and thus define them. They are, of course, not tangible things but concepts—which, when they refer to substances, are qualifying attributes expressed by adjectives such as combustible, univalent, triclinic, vertebrate, parasitic; and when they are made the abstract objects of discussion become substantive and are expressed by nouns such as combustibility, univalence, triclinicity, backbonyness, parasitism. Further illustrations of this sort will make it quite clear that the mystery of the world of essence is merely the product of a naïve confusion of thought precisely like that which is nowadays evident in the ingenuous or whimsical imaginings of those who try to picture a burglar entering a bank-vault through the fourth dimension. Those who are familiar with alchemical theory will recognize the same sort of confusion in the thought of those sooty spagyrists who attempted to manipulate the three alchemical essences or Principles, their philosophical mercury, sulphur and salt—which were fluid metallicity, combustibility and vitriosity—as if they were corporeal things.

No such confusion affects the thought of Aristotle. He perceives, simply, that by their physical properties, or essences, all substances may be unequivocally discriminated and compared, and identified as individuals of definite *species,* or substances of a second conceptual order, which chemists who think of copper and caustic soda and sucrose call substances, without qualification, but which biologists who think of chimpanzees and roses and pneumococci still call species. These species, thus defined by their essences (and not otherwise truly defined), are now seen to fall into natural classes themselves definable by that which is common to particular groups of essences, namely

the essence of a more inclusive *genus*. The biologist still finds it convenient, if not necessary, to identify the multifarious species of animals and plants with reference to these genera, as *homo sapiens*, *drosophila melanogaster*, *solanum tuberosum*, and so on; and chemists do likewise, though more confusedly, when they speak of *potassium cyanide* or *diparaamidothiodiphenylamine*. And the genera may likewise be grouped in successive classes of higher order. Note that all these classes are real, but incorporeal and definable only diagrammatically or symbolically, that is, by abstract ideas which are essences and that they persist, though individual organisms die and compounds are transformed.

This is enough to illustrate the grosser outlines of Aristotle's envisagement of the natural order. The Academics before him had taken the first steps toward such classification, but their taxonomy was confined to the futile arrangement of pure ideas as such. It was Aristotle who first discerned this generic type of relation among things perceived, recognized its universality, realized its significance as the basis of all knowledge, and pointed out the possibility of its development to extreme exactitude by increasingly minute and discriminating observation. He developed its implications subtly and elaborately, and identified it with the order of deductive thought. Species and genera, once determined by observation and inductive inference, typified in their complicated relations the relations of all ideas. The *syllogism* is nothing other than the statement of the simplest generic relation:

The individual Socrates is of the species man.
The species man is of the genus mortal being.
Therefore Socrates is of this genus and is mortal.

In the *Analytica* he reduced the most complicated of deductive processes to this simple type, the "first figure of the syllogism." J. S. Mill properly criticised this sort of reasoning as circular, since all general premises presuppose a knowledge which the conclusion merely makes explicit. I hardly think that Aristotle would have disputed this: but he might well have pointed out that latent knowledge is merely potential, and does not become actual until it is made explicit: there are very few of us who can determine by mere inspection the real roots of a cubic equation. He developed no fixed method of inductive logic, for the simple reason that there can be no such thing; since, as he knew, the process is one of observation and comparison, and effective procedures in this sort of thinking are many.

Aristotle does not, in his theoretical works, actually apply this scheme of thought, and so develop it. He does, however, call attention to the several aspects of phenomena with reference to which, inevitably, they are described and become by conceptual definition known. These are the *Categories:* we might call them conditions of actual existence. They are also ways of knowing and primary forms of assertion. To know a thing we must know where it is, when it occurs, how it affects our senses, how much it is, how it acts or is affected by action, and what its relations are to other things; or, to use the customary formula, we must know it as Substance, and with reference to Space, Time, Quality, Quantity, Activity, Passivity and Relation. These categories overlap, but they are exhaustive.

In physics today we have reduced their number—sometimes uniting Space and Time in a four-dimensional continuum, considering time (if I may be forgiven) an imaginary distance; wholly eliminating Passivity by the law of action and reaction; and determining Quality by measurement, thus representing it by, if not actually reducing it to Quantity. But these are all theoretical innovations, the philosophical import of which appears not to be settled yet. There are those who still believe that there is something essentially different in Space and Time: that being large and being old are not in any sense the same; though growing up and growing old are related, being different aspects of a single process of change; and Aristotle himself said that all change involves and may be determined by motion in space (a pregnant remark!) from which motion, he also said, we derive the conceptions of space and time. In practise, further, we are still compelled to define many passivities, without reference to specific reacting forces, as hardness or elasticity or breaking strength, and so on. The definition of qualities by quantitative measurements, finally, is not yet universal, and if compulsory would be sometimes very awkward in chemical, biological, and other scientific practise. In short, when we alter these categories we depart from the actual sensory world which Aristotle studied and which remains the only complete reality; our conceptual representations being, in fact, diagrammatic and imperfectly so at best.

Now, all this representation of substances, essences, species, genera and logical categories refers only to the permanent structure of the world—or rather, to its structural plan, which is the same as that of our reflective thought. But Aristotle was interested, and intensely so, in the phenomena of change: of movement, generation and corruption,

material transformation. Beneath all his detailed criticism of the theories of his predecessors there frequently appears the fundamental objection that they are defective in not attempting to explain occurrences as well as things. This, he observes, is the primary defect of the whole Pythagorean-Eleatic-Platonic complex of doctrines. Those of other philosophers, notably Heraclitus and the Atomists, show deeper insight, for they are dynamic. Even in them, however, theory remains inadequate in not taking into account the actually determinate character of all processes of change. Heraclitus' conceptions of cyclic process and dynamic equilibrium are incidental features in a theory of universal flux, whereas actual changes—if we except the motion of the stars—have beginning and end in fixed substantial forms: water changes to air, bog-ore to iron, acorn to oak. The doctrine of the Atomists is even less acceptable; for the random motion they imagine would produce not a limited but an infinite number of types of change, which is contrary to fact, and this with no regularity of process, which is again contrary to fact.

To meet these objections, Aristotle proposes his *four causes*, which may be thought of as analogous to the categories in that they refer to the determining conditions of all change, these being at the same time necessary inferences from the phenomena—aspects of nature again—and also ways of knowing. There must be something to change—a material cause; an action or potency to start it—an efficient cause; a necessity which makes it follow a definite course always the same in similar circumstances—a formal cause; and finally a purpose, defined by its end—a final cause. The material cause is matter, Aristotle's indeterminate substratum actually existent only in substances, which we quantify as mass; the efficient cause we call energy,—mechanical, chemical or vital; the formal cause, natural law. The final cause we ignore in science, not because there is no purpose in nature, for there is purpose in nature, at least in men and higher animals; but because it does not assist us to understand phenomena. To Aristotle, however, the phenomena of life, in which he was most intensely interested, were inexplicable without it: he had to include it, or leave his own system in one aspect defective like the others. Also, the reasonableness which all Greeks from first to last imagined as latent in nature, that immanent intelligibility which accounted for the possibility of understanding, was doubtless very vivid to the thinker who had discovered the exact correspondence of the forms of nature and the forms of thought, and worked to the same end. He conceived all nature, therefore, as

purposeful, and thought of formal causes as evidences of intelligent guidance determined by the final cause of all—a divine intention, not supernatural but, like the physical world which was its embodiment, eternal. This was his *entelechy*. His system, unlike our own, was teleological; and like those that preceded it culminated in a conception that we call extra-scientific, that is, the conception of the divine. In this sense it became a theology: Aristotle himself gave his First Philosophy this alternative title.

This introduces us to that part of the philosophy we are considering upon which the interest of metaphysicians is still focused. Jaeger himself devotes the greater part of his criticism to the development of Aristotle's theological doctrine; not only because of its historical importance, I think, but also because it still appears to him, as a philosopher, the most important aspect of his great predecessor's thought. You will not blame this distinguished scholar for any of the tedium you may have felt during the preceding discussion: its familiar matter he doesn't mention at all, not even to refer to its scientific implications.

What, then, is this theology? Let me, first of all, refer once more to the text of the *Metaphysics*, in order to make clear its philosophical basis, which, as I have already indicated, is the general conception there presented of the world of nature. The first step toward a consideration of the transcendental is taken when we meditate upon the most general of all ideas, that of existence. What, then, transcends this world of nature and its reflection in reason? In the most comprehensive meaning of the words, What *is?* At this point Aristotle's meditation carries him to what will at first seem, even to a scientist, a radical empirical extreme. He answers, in effect —"Nothing transcends the world of nature; indeed there *is* nothing, really, but what is *known*." In short, he identifies that which is with that which is known; which means for him, we must remember, known exclusively through experience. There is always the possibility of new experience: the natural world has this potency. But Aristotle means by potency exactly what we do when we refer to gravitational or thermodynamic potential or potential energy in general: not a mystical pervasive complex of indeterminate influences, the primitive *Mana*, a participative feeling of which is the beginning of religion, but merely a blanket term which designates a number of specific potentials (let us say), each definable by its actual effect. Aristotle criticises sharply a philosopher

he rather admires, Anaxagoras of Clazomene, for ascribing the origin of things to an indeterminate mixture. There is no such thing, he argues, because it cannot be defined. Nothing really *is* but the content of knowledge; for the word "is" has no meaning unless it refers to something: no predication can be made about the unknown. Things may come into being; but before they are known they *are* not, and can be said to be possible only by inference from an actual event.

We might try to amend this statement by saying that all this is so, but only so far as we are concerned; that other animals with senses different from ours may know things not known to us, which are therefore actual to them; and that we all, including Aristotle himself, believe that the world existed before there were any human beings to know it. But note that these statements all express possibilities only: it cannot be categorically asserted that animals do know what is unknown to us, much less what they know, until we are able to infer from our own knowledge of their behavior that they do perceive directly something (like sounds of high pitch or odors) which we perceive otherwise, or from other knowledge infer to be existent. Then we may assert not only that they do sense what we cannot, but that they did formerly sense what we could not. In the same way we may assert that the earth existed before there were human beings to know it, but only after we can infer from a mass of present knowledge that this must have been so; and then, this fact is a part of knowledge. When we speak of Being, says Aristotle, we mean the known; all else is not-Being.

Note that this not-Being includes all that is indeterminate in any way: space unoccupied or unbounded by substance; or, in any sense whatever, the infinite, since only the finite is actual; or potency not specifically designated by some actual effect; or matter deprived of form,—that is, substance without attributes—but not pure form, for this, though incorporeal, may be conceived with reference to the actual—not only as some common abstract idea, but as figure and number, arithmetic form, type of logical relation, or mode of behavior. In short, anything definable may exist; but nothing indefinable, for the indefinite cannot be thought about, excepting by negation.

Aristotle's final theology is consistent with these premises. Jaeger describes its development most interestingly, at length; our own divergent interest permits us to summarize his findings briefly. In the treatise *On Philosophy*, referring to religious rituals, Aristotle says: "Those who are being initiated are not required to grasp any-

thing with the understanding (μαθεῖν), but to have a certain inner experience (παθεῖν), and so to be put into a particular frame of mind, presuming that they are capable of this frame of mind in the first place." He thus sharply separates the religious from the theoretical interest; and his theology becomes a part of his physics, the superstructure of his theory of nature, or, as our ancestors expressed it, "the Queen of the Sciences"—in a word, a natural theology.

To find his evidences of the divine he contemplates the heavens, like the old Pythagoreans and like multitudes of other men, before and after. Up there, the changeless stars at immeasurable distances move eternally in their circular courses, measuring endless time. This motion is natural to the heavens and proves them to be of other substance than any we know in this thick vapor which surrounds us on Mother Earth, where everything when unconstrained moves up or down. The purer air above us becomes transformed beyond the moon, where only the purest exhalations penetrate; it becomes celestial aether, an essence *sui generis*. Within these silent realms all movement is spontaneous, for here it originates: the stars are living beings, therefore, of purest substance, nourished by the finest exhalations; and since this is so, their conscious minds are more intelligent than it is possible for us to conceive; for did not Hippocrates show that the purest foods and airs and waters produce in men the finest minds? The stars' spontaneous movements, however, are all the same, and even the wandering planets below them share in their ceaseless daily revolution. This proves the presence in the furthest celestial realm of a single Potency that guides them all: a first cause of movement, itself quiescent Form; the divine Essence, which is God. Not the Creator, for the cosmos is uncreated, eternal: not the Idea of the Good, unless one sees supreme good in supreme intelligence and the perfection of its actualization in celestial movement; for there is no Providence in Aristotle's heaven, only power. His God is the divine potential energy that animates the world.

In the twelfth book of the *Metaphysics*, called *Lambda*, Aristotle develops these conceptions and defends them by arguments to prove the actuality of the divine in nature; that is to say, the existence of God as thus conceived. Of this book, the first seven chapters are coherent doctrine; but the eighth, which superimposes fresh arguments that are clearly intended to clarify the preceding by a more minute analysis of the phenomena, introduces in so doing remarkable inconsistencies and corresponding doubt, as if the scientist were driven by

force of detailed evidence to question his prior conclusions and reconstruct his theory. Jaeger shows that the coherent books are old, dating from the period of the treatise *On Philosophy*, but that the eighth is much later, the product of further studies finally matured. Its reconsideration of the earlier doctrine is based on the mathematical analysis of celestial motions made by Eudoxus, from which this astronomer deduced the first purely scientific planetary theory—the system of homocentric spheres which Aristotle had accepted as the basis of his own physical cosmology. This showed that although all planetary movements could be conceived as if they were the resultants of uniform circular revolutions variously compounded, each one of these composite movements was peculiar; and Aristotle found himself unable to account for their striking differences by the assumption of a single physically definable cause. In the terms of his doctrine this meant that the question was left open as to whether the primary potency, the divine essence, were one or many; in short, whether or not it was possible to infer from the phenomena the presence of one Omnipotent God.

Thus Aristotle's natural theology broke down. Confessing failure, he abandoned it, leaving to his successors, in place of a definitive theology, an unsolved problem. His last words upon the matter imply a mood which closely approaches to agnosticism. He writes, referring to his own physical model of the cosmos: "Let this, then, be taken as the number of the spheres (the carrying spheres of the planets), so that the unmovable substances and principles may probably be taken as just so many: the assertion of necessity must be left to more powerful thinkers." And again in the *Physics:* "Motion, then, being natural, the first mover, if there is but one, will be eternal also; if there are more than one, there will be a plurality of such movers. We ought, however, to suppose that there is one rather than many, and a finite rather than an infinite number . . . and in this case it is sufficient to assume only one mover." This expresses his final attitude toward the problem. The question is open; but for methodical reasons, and in accord with the principle of parsimony, it will be better to assume one ultimate essence.

These statements do not at all suggest the temper which we associate with theology. In Aristotle's thought religious feeling is completely dissociated from his theory of the cosmos; he clings instinctively to a monistic view of the world as the most of us do today; but perceives, as frequently we do not, that this view is not a neces-

sary inference from phenomena, but a postulate, which is to be justified on methodical, that is to say, on pragmatic, grounds. I think you will agree with me that this final doctrine looks much more like theoretical physics than anything else. A man of science is inclined to wonder why, even in its original form, it was ever called by Christians a theology. In reality this was an historical accident: a falsification of its original tone, due to the reintroduction by scholastic commentators of that religious feeling which Aristotle had excluded from it. The God he conceived,—a universal Potency actualized in celestial motion, the pure Form that defines the nature of cosmic Power—what would this have been if a miracle had revealed it to his searching thought? Would it not have been what it is to us: the Form, or as we say, the Law, of Universal Gravitation?

The critical revision of Aristotle's theoretical works, which produced the final texts of the *Physica*, the *Metaphysica*, the *Analytica*, the *de Caelo* and the *De Generatione et Corruptione*, was made after Alexander succeeded to the throne of Macedonia, and left the philosopher free to return to Athens, there to organize his own philosophical school, the Lyceum. Perhaps the most significant result of Jaeger's critical work is his definitive reconstruction of this establishment. It was not at all a school of philosophy of the familiar Greek type, but something entirely new: an institute of scientific research, where students assembled, not to sharpen their wits and stimulate their creative thought by lively dialectical disputation about the nature of things in general, but instead to listen to formal lectures: some on the biology and medicine of the day, illustrated by specimens of animals and plants, anatomical charts and similar demonstrative apparatus; some on meteorology or geography, or the history of events; others on mathematics, theoretical music and astronomy, or on the critical history of philosophy. Thus the natural sciences were taught each as a particular discipline and were coördinated by historical and critical studies. This education led directly to the prosecution of specialized research by those whose taste and aptitude encouraged it, each in a chosen field, and made possible certain coöperative investigations in historical and biological studies directed by Aristotle himself.

From the beginning, the new work undertaken by the school was exclusively scientific. Aristotle himself, with the probable assistance of his students, then wrote those works that mark the beginning of

scientific scholarship—the histories, based on records and inscriptions, which include his encyclopaedic survey of the constitutions of the Greek city states. Then also he compiled the *Historia Animalium*, and wrote his extensive treatises on the gross anatomy, the movements and the reproduction of animals, and on physiological psychology, together with many shorter monographs on particular biological phenomena. In consideration of the fact, which Aristotle himself asks us to remember, that this was the first work ever done in comparative biology, its results are admirable: its method is altogether predominantly inductive, its findings being based not so much on the evidence of common report as on the results of patient and careful observations, in part experimental and frequently remarkably accurate; and its critical tone, particularly in the discussion of prevalent beliefs concerning dreams, divination, prophecy and so on, is wholesomely sceptical. This work marks the dominance of the philosopher's maturest thought by unequivocally scientific interests, and is convincing evidence of his ability in scientific research, even when this is unfairly judged by present standards. His critical syntheses of work in other fields is based, of necessity, on the findings of others, and only too frequently reflects the ignorance of his time, especially in mechanics, where it is developed (probably in greater part by his successors) from reasonable but untested and erratic premises. Such defects, however, whenever the works in which they occur may be considered his own, are obviously to be attributed not to a persistent predilection for *a priori* reasoning quite inconsistent with the whole character of his later writings, but rather to the impossibility that one man could check the data in all fields of research.

It seems to me, moreover, that, important as these investigations were, they are of less significance as contributions to knowledge than as evidence of the complete emancipation of critically philosophical thought at the beginning of the Alexandrian Age from the insidious influence of those mystical vagaries which, through the teachings of the Academy, had threatened and very nearly accomplished the total extinction of Greek natural science. That this calamity was averted was due to the unaided effort of a single great man whose penetrating acumen and conceptual grasp and whose uncompromising intellectual integrity were powerful enough not only to disencumber his own mind of these hypnotic influences, even against the persuasions of a venerated teacher reiterated during twenty years, but to turn the whole tide of philosophical inquiry back again through the original channel

of its flood to the disinterested investigation of nature. The achievement was magnificent.

But Aristotle not only turned the tide: by the organization of his school he ensured its continued flow. After him, his friend and successor Theophrastus, criticizing destructively the metaphysical superstructure of his earlier philosophy, pronounced all theology transcendental and excluded it from scientific consideration; in the next generation Strato of Lampsacus likewise discarded the conception of final cause. A multitude of scientific works, inspired by the spirit of the master's own researches, were produced by the school: the critical history of philosophy of Theophrastus, the history of mathematics of Eudemus, the botany of Theophrastus and his work on minerals, the theoretical music of Aristoxenus, the geography of Dicaearchus, and many others. It is often remarked that the Peripatetic school produced no men of great talent after Strato. This, I think, means that it produced no speculative philosophers of distinction; and this is true. But if its influence on the progress of thought be thus incautiously estimated, the judgment is quite fallacious. Those who inherited the Peripatetic tradition and practised its methods were not philosophers, but scientists—it was the school itself which established this distinction—and among them were many of the very greatest thinkers of antiquity.

The Alexandrian Age was the ancient Golden Age of Science. The empirical tendency of all Greek philosophy in the three centuries that followed Aristotle's death is a very striking fact, and its association with an increasingly sceptical spirit no less so. The Museum at Alexandria, founded by Ptolemy Philadelphus and organized in accordance with the sought advice of the Peripatetics Demetrius of Phalerum and Strato of Lampsacus, was something very like an enlarged Lyceum—another great institute of research. It became the most important center of that renewed intellectual stimulation which ultimately gave to the world the finest products of Greek scientific genius: the technology of Ctesibius and Hero, the mathematics of Archimedes and Apollonius; the astronomy of Aristarchus of Samos, Eratosthenes, Hipparchus and Ptolemy; the anatomy of Herophilus and Erasistratus—which came in part directly from that Metrodorus who had taught in the Lyceum—and the experimental physiology of Galen; the cultural anthropology of which we have fragments in the works of Callimachus; the history of Polybius and of the doxographers who handed down the Peripatetic history of science; the geography of

Strabo; the literary criticism of Aristarchus of Samothrace and other distinguished scholars who edited and preserved the ancient classics and standardized the Greek language; and the sceptical philosophy of Pyrrho, Carneades, Aenesidemus and Sextus Empiricus whose critical labors long perpetuated, even against the rising tide of supernaturalism which finally overwhelmed it, that methodical philosophy which, almost completely disregarded until our own time, we are forced to recognize as the explicit formulation of the principles of scientific judgment which we now universally—though not always consciously—accept as valid.

In the entire range of human experience up to the time of Kepler and Galileo there is no intellectual achievement that can bear comparison with this. Without doubt it was stimulated in particular ways—especially in mathematics and in medicine—by the work of Aristotle's predecessors: by the latter Pythagoreans and the school of Eudoxus, by the medical schools of Cos and Cnidus, and otherwise; and doubtless also it was encouraged by the practical spirit that universally characterized the early Alexandrian temper, and by the agnosticism that then prevailed among the intellectual classes. There is, however, the most conclusive evidence that no single influence affected it as significantly as that of the Peripatetic school, the school of Aristotle; which, guided by his undying spirit, determined the character, and fixed the intellectual standards of the most powerful educational establishments of the age.

Such was the work of Aristotle. Interpreted by the medieval scholastics and by their spiritual descendants among modern speculative philosophers—whose predispositions have naturally led them to value most highly the early philosophical conceptions that linked his thought with that of the greatest religious thinker of antiquity—he has become almost universally known as the father of transcendental metaphysics. But the labors of an acutely critical scholar, clarifying at last the history of his intellectual life, now leave no room for doubt that, judged by the final outcome of his thought and labor, he belongs not to the theologians but to us: the greatest of ancient metaphysicians who became in maturity the founder of critical natural philosophy, and of systematic scientific research.

BOTANY.—*Notes on the Myristicaceae of Amazonian Brazil, with descriptions of new species.* II.[1] ADOLPHO DUCKE. (Communicated by E. P. Killip.)

VIROLA Aubl.

Synopsis of the species (principally from Amazonian Brazil) according to the characters of the fruit and of the androecium.

A. Fruit densely covered with soft-velvety subpersistent hairs which are ramified in numerous short lateral spurs; pericarp rather thin.
  a. Length of these hairs up to 8–9 mm Anthers connate, commonly subobtuse at the apex, slightly longer than the androecium column. 1. *V. loretensis* A. C. Smith.
  b. Length of these hairs up to 3–4 mm Anthers free in terminal part, a little divergent at the apex, very much longer than the androecium column. 3. *V. divergens* n. sp.

 The following probably should also be included in group A:
  c. 2. *V. mollissima* (A. DC.) Warb. Female plant unknown. Indumentum nearly like in *V. loretensis?* Anthers connate, very much longer than the androecium column. Leaves very large. Eastern Peru. Not seen.
  d. *V. urbaniana* Warb. Female plant unknown. Anthers like *V. divergens,* according to the description. Goyaz. Not seen.

B. Fruit covered with easily deciduous tomentum composed of very small (0.1–0.2 mm long) stellate hairs; pericarp thin. Anthers very much longer than the column, lineal or narrowed to the apex.
  a. Fruit ellipsoid, 11–16 mm long and 10–12 mm broad. Trees of upland forests and of "campos" woods. 4. *V. sebifera* Aubl., 5. *V. mocoa* (A. DC.) Warb., and 7. *V. rufula* Warb.
  b. Fruit almost globose, 7–12 mm in diameter. Tree of the periodically inundable forest. 9. *V. cuspidata* (Benth.) Warb.
  c. Fruit (according to Warburg) globose-ovoid, up to 27 mm long; not seen. Pozuzu (Peru). A male plant I found at Rio Purús (State of Amazonas, Brazil) belongs perhaps to this species. 6. *V. peruviana* (A. DC.) Warb.

C. Fruit with indument as in B, ellipsoid, 15–18 mm long, 12–14 mm broad, with thin pericarp. Anthers nearly as long as the column. Forest tree of the hylaea. 10. *V. venosa* (Benth.) Warb. The two species *V. sessilis* (A. DC.) Warb. and *V. subsessilis* (Benth.) Warb. are "campos" shrubs of central Brazil, remarkable for their very small size and for their sessile or subsessile leaves; their fruits are covered with a more or less deciduous tomentum. I have seen fruits of *V. subsessilis* (State of Bahia, *Zehntner* 516=3054); they are oblong-obovoid, 15–20 mm long and 8–9 mm thick; their pericarp is a little thick but hard, covered with very minute stellate hairs. The fruits of *V. sessilis* are, according to Warburg, subglobose.

D. Adult fruits glabrous, pericarp thick. Anthers as long as or shorter than the androecium column.
  a. The thinner but more rigid coriaceous pericarp keeps its original form when dry. Fruits more or less globose or ovate-ellipsoid.

[1] Notes on the Myristicaceae of Amazonian Brazil, with descriptions of new species. I. This JOURNAL **26**: 213. 1936. Received February 15, 1936.

I. Fruits 15–22 mm thick. From Ceará to the Guianas and Lesser Antilles. 11. *V. surinamensis* (Rol.) Warb.

II. Fruits 20–35 mm thick. From Rio de Janeiro and Minas Geraës to Santa Catharina. *V. gardneri* (DC.) Warb. and *V. bicuhyba* (Schott) Warb.

b. The very thick but more fleshy pericarp twisted and wrinkled irregularly and roughly when dry. Fruits generally ellipsoid.

I. Fruits (of our specimens) 20–30 mm long. 12. *V. carinata* (Benth.) Warb.

II. Fruits 30–40 mm long. 13. *V. albidiflora* n. sp.

III. Fruits about 30 mm long. Male plant unknown. Northwestern Matto Grosso. Not seen. *V. elliptica* A. C. Smith.

IV. Species of the affinity of the three last, but the female plant is unknown. Eastern Peru. Not seen. *V. weberbaueri* Mgf.

E. Fruit densely hispid-velvet with persistent hairs (ramified in numerous short lateral spurs), ovate or obovate-ellipsoid, about 30 mm long and 20 mm broad, with hard and thick ligneous-coriaceous pericarp. Anthers shorter than the androecium column.

a. Length of hairs of fruits 0.5–1.5 mm 17. *V. multinervia* n. sp.

b. Length of these hairs 2–2.5 mm 18. *V. decorticans* n. sp.

c. 16. *V. multicostata* n. sp., 15. *V. crebrinervia* n. sp., 14. *V. minutiflora* n. sp., *V. rugulosa* Spruce ex Warb., and *V. mycetis* Pulle may belong in this group; the female plants are, however, unknown. I have not seen the two last species.

F. Fruits very minutely rugose, covered with a thin but persistent tomentum of microscopic stellate hairs, oblong or obovate-ellipsoid, 15–20 mm long, about 10 mm thick; pericarp rather hard. Anthers about as long as the column, or shorter. 19. *V. calophylla* Spruce and 20. *V. calophylloidea* Mgf.

G. Fruit unknown. Anthers shorter than the column. The aspect of this plant is very peculiar and shows no affinity with the other species. 21. *V. parvifolia* n. sp.

1. VIROLA LORETENSIS A. C. Smith, 1931, floriferous (*V. villosa* Ducke, 1932, fructiferous). A small tree, remarkable for its few ramified, hanging, flexuous, often elongate inflorescences (up to 30 cm when fructiferous), and for its partly long and rather woolly indument. The subglobose-ellipsoid fruits 2 cm long are densely velvety with soft, articulate and shortly spur-branched hairs, up to 8 or 9 mm long. This indument seems to be more or less deciduous after the fruits mature. The staminate flowers correspond rather to the section *Amblyanthera* of Warburg; the connate anthers have the apex slightly obtuse, their length (when completely developed) equaling or slightly exceeding that of the column. It grows in the inundable forest along the rivers and sometimes in very moist upland forests, in argillaceous soils. Its geographic area includes Amazonian Peru, where it was found near Iquitos by Killip and Smith, by Kuhlmann, and by myself, and the westernmost region of the Brazilian Amazon (Lower Japurá and Lower Javary), where, in the service of the late Dr. Huber, I collected specimens which are now in the Pará Museum (Herb. Amaz. 6792 and 7419).

2. VIROLA MOLLISSIMA (A. DC.) Warb., of Eastern Peru, seems to be

allied to *V. loretensis*, but is easily distinguished by its very large leaves and by its anthers, which according to all authors are like those of the common *V. sebifera*. I have not yet found it.

3. **Virola divergens** Ducke, n. sp. Speciebus *V. sebifera* (in Amazoniae dimidio orientali communi) et *V. urbaniana* (mihi solum e descriptione nota) affinis. A prima differt: partibus omnibus aliquanto maioribus et robustioribus, indumento densiore et aliquanto longiore, antheris parte superiore non connatis subdivergentibus, fructibus maioribus et longe densissimeque rufovillosis; a secunda (fructu ignoto) differt praesertim bracteis parvis caducissimis. Arbor parva vel mediocris; folia vulgo 20–30 cm longa, in individuis masculis saepius angustiora quam in femineis, saepe magis oblonga et marginibus magis parallelis quam in specie *V. sebifera*; costae secundariae vulgo utrinque 15–22, ut venulae transversae subtus pilositate longiore densiore et saturatius rufa notatae; inflorescentiae utriusque sexus saepe longiores et ampliores quam in specie citata; androeceum breviter stipitatum antheris 3 parte superiore non connatis subdivergentibus apice acutis; fructus maturus brevissime pedicellatus, globosus vel elliptico-globosus 2.5–3 cm diametro, undique pilis mollibus detergibilibus pulchre rufis vulgo 3–4.5 mm longis articulatis et brevissime spinuloso-ramosis densissime subvilloso-velutinus, pericarpio mediocriter tenui sat fragili, seminis arillodio purpureo a basi laciniato, testa distincte sulcata.

Habitat in silva primaria non inundabili circa Manáos, leg. A. Ducke: loco Estrada do Aleixo, florifera, arbor mascula 27-4-1932, Herb. Jard. Bot. Rio 24550, feminea 15-5-1932, Herb. Jard. Bot. Rio 24548; loco Estrada do Tarumá, fructifera, 2-12-1932, Herb. Jard. Bot. Rio 24549). Prope Porto Velho fluminis Madeira leg. J. G. Kuhlmann 8-9-1923 (arbor feminea flor., Herb. Jard. Bot. Rio 24547).

This species, when floriferous, may be mistaken for luxuriant and densely tomentose individuals of the common *V. sebifera;* the anthers are, however, free at their apex, as in the central Brazilian species *V. urbaniana* Warb. It may be at once distinguished by its fruits, which are densely covered with rather long, articulate and spur-branched silky hairs of a beautiful red brown. *V. loretensis* has the fruits rather similar but with much longer articulate hairs; in all other characters it is very different.

4. VIROLA SEBIFERA Aubl. This widely distributed species is common from the Guianas through the whole State of Pará to the State of Maranhão (Anil, near S. Luiz, Herb. Gen. Mus. Pará 517); it grows principally in secondary forest and in rather dry woods of the "campos" regions. In the State of Amazonas it is less frequent; I have not found it around Manáos. It is, however, mentioned by Warburg for the Solimões region (Tiffé, the ancient Ega) and for eastern Peru (Tarapoto). I think I must refer to this species a tree of the upland rain-forest of Seringal Iracema (Rio Acre, Territorio Acre), Herb. Jard. Bot. Rio 24551, the leaves of which are more membranous and less tomentose than in the typical form. The geographic area of *V. sebifera* includes the whole hylaea, the central part of Matto Grosso, the State of Goyaz, and the northern half of the State of São Paulo; I have seen herbarium specimens from all these regions.

5. Virola mocoa (A. DC.) Warb. Our herbarium has now an excellent representation of this species, which is allied to *V. sebifera*. It differs only in its non-cordate leaves, which have more distant nerves and more dense and uniform indument beneath. The fruits are not different from those of *V. sebifera*, their form being only a little more subglobose; they have the same ferruginous deciduous tomentum of exceedingly small stellate hairs. The tree, according to the collector, attains no more than 8 meters. Our specimens come from the type locality: Yurimaguas, Eastern Peru, Herb. Jard. Bot. Rio 23688 (male) and 24546 (female tree, with flowers and adult fruits), coll. J. G. Kuhlmann.

6. Virola peruviana (A. DC.) Warb. A medium-sized tree of the scarcely inundable forest along the banks of the Rio Purús above the mouth of the Rio Acre (State of Amazonas) corresponds rather well to the description in Warburg's monograph, but the leaves are membranous. Out of many floriferous individuals I have found only male trees (Herb. Jard. Bot. Rio 24552).

7. Virola rufula Warb. Our herbarium specimens, viz. 24495 (male), 24497 (female, floriferous) and 24496 (fructiferous), from São Paulo de Olivença (Rio Solimões), 24498 (male), from S. Gabriel (Upper Rio Negro), correspond very well to the description in Warburg's monograph, the type coming from Coary (Rio Solimões). This species differs very little from *V. sebifera*, but its leaves are a little more oblong-lanceolate, membranous, pale or glaucous, and very scantily hairy beneath; the fruit resembles that of *V. sebifera*, having the same dense but deciduous ferruginous tomentum of minute stellate hairs. It grows to medium size in upland forest, especially where the growth is less dense or partly secondary.

We have also nos. 24541, 24542, and 24544, all male, from the upland forest northeast of Manáos, where the trees grow in the same conditions as above mentioned, which probably belong to the same species. Their leaves vary greatly in width, sometimes on the same branch; many of them have the broad form of those of *V. sebifera*, while others are narrow and oblong-lanceolate as in *V. cuspidata:* texture, color, and the faint tomentum are as in true *V. rufula*. I have not seen fructiferous material. No. 24545, male, from the Upper Rio Negro at the limit between the upland and the inundable vegetation, differs from the others only in its still longer leaf-apex. No. 24505, female, floriferous, from the Rio Ouro Preto, affluent of the Rio Pacanova, northwestern Matto Grosso, has more elongate leaves and more developed tomentum.

8. Virola theiodora (Spruce ex Benth.) Warb., from Manáos, may not differ from *V. rufula*, but according to the description the leaves are broader and thicker. We may, however, note that the type consists of fructiferous twigs. Warburg considers the rugose or undulate testa as the best differential character, but the fruits he had seen were not ripe, and their seeds may have become rugose when dry. The tea-smell, referred to by Spruce, can be

noted in dry leaves of many of the *Virola* species; it is not restricted to *V. theiodora.*

9. VIROLA CUSPIDATA (Benth.)Warb. (*V. elongata* (Benth.) Warb.) Very similar to certain forms of *V. rufula*, but the trees are always small; the leaves are extremely variable in the width of the base but are more distinctly lanceolate-oblong or ovate-lanceolate, terminating often in a very long point; they are always less tomentose than those of *V. sebifera*, but more strongly tomentose than those of *V. rufula;* the fruits are a little smaller than in either, and are globose rather than ellipsoid, having the same tomentum. This species is limited to the margins of lakes and rivers of the Middle and Upper Amazon, periodically subject to a long and deep inundation; in many parts of the Rio Negro, Trombetas, and Tapajoz it is a common and characteristic element of the flora. I have not as yet observed any other Myristicaceae in identical conditions except *V. surinamensis*, which is confined, in Amazonia, to the estuary and coastal region. I have observed *V. cuspidata* also in Upper Amazonia, at the Lower Javary, and Ule collected it at the Lower Juruá (5024) and at the Juruá Miry, Territory of Acre (5709). Our herbarium specimens come from the environs of Manáos (Rio Tarumá, Herb. Jard. Bot. Rio 24467, and Uypiranga, 24770, male plants; Lake Marapatá, 24469, fructiferous plant), from the Upper Rio Negro above the mouth of the Curicuriary (24446, male), from Boa Vista do Arary down to Itacoatiara (24465, male), and from Itaituba, Rio Tapajoz (24468, fructiferous).

I fail to find any distinctions between *V. cuspidata* and *V. elongata;* both leaf forms are very often found in the same tree. The varieties *punctata* and *membranacea* are only insignificant forms. I do not know whether *V. elongata* var. *subcordata* should be included here, as I have only seen an old male specimen from the Cassiquiare region (*Spruce* 3172).

10. VIROLA VENOSA (Benth.) Warb. This species, widely distributed through the hylaea from the coastal region to the Upper Amazon, is an upland forest tree, of small or middle size when in secondary formations, but rather large when in virgin growth. Frequent near Manáos (Herb. Jard. Bot. Rio 24500, male; 24499, female tree, floriferous and fructiferous); these specimens are exactly like the type, which I have seen. The ripe fruits are 15–18 mm long and 12–14 mm thick; they resemble in form and in the tomentum (which is ferruginous, deciduous, and composed of minute stellate hairs) those of *V. sebifera*, having a little thicker pericarp; the red ariloid is laciniate. These fruits are not described in Warburg's monograph; they have nothing to do with the fruits of *V. venosa* var. *pavonis* Warb. (of Andean Peru), which evidently does not belong to our species, having axillary inflorescences (the true *V. venosa* seems to have always pseudo-terminal inflorescences, sometimes at the summit of leafless lateral twigs). *V. venosa* var. *martii* Warb., from the Japurá, has also much larger fruits than our species and must be separated from it.

I have also gathered male plants of *V. venosa:* near Belem do Pará (Herb. Amaz. Mus. Pará 15849); at Bargança near the eastern Atlantic coast of Pará (Herb. Jard. Bot. Rio 19569, slightly different from the species type in its leaf base, which is nearly as acute as in *V. surinamensis*); at Itaituba and along the lower cataracts of Rio Tapajoz (Herb. Jard. Bot. Rio 18630 and 2702); in the Lower Trombetas region (Herb. Amaz. Mus. Pará 12042); near Tocantins, Upper Amazon (Herb. Jard. Bot. Rio 19570). Certain leaves of the last specimen have nearly parallel sides as in *V. carinata,* but the inflorescences are surely those of *V. venosa.* I have also seen a specimen collected at the Rio Marmellos, tributary of the Lower Madeira (*Ule* 6115, male).

11. Virola surinamensis (Rol.) Warb. This widely distributed and well known species grows in some of the Lesser Antilles, Trinidad, the Guianas, southern Venezuela, and the northernmost part of the Brazilian State of Amazonas (Rio Surumú, *Ule* 7988), the coastal region of Pará including the whole Amazon estuary, the northern part of Maranhão, and northwestern Ceará (Comarca de Granja, foot of the Serra Ibiapaba, in marshy ground near water, M. A. Lisboa, Herb. Mus. Pará 2436). It is extremely abundant in the low islands of the great estuary, inundable by the Atlantic tide; in some of these it represents the majority of the rather large trees up to 20 meters high. The enormous quantities of "ucuhúba" seeds yearly exported from Pará, or there consumed in industries, come from this species. By its rather large globose, glabrous fruits, it is distinguishable easily from other species, certain forms of which may resemble it (e.g. *V. carinata, V. venosa*).

12. Virola carinata (Benth.) Warb. A middle-sized or rather large tree which grows along small upland forest streamlets in marshy but not inundable soils. Frequent around Manáos (Herb. Jard. Bot. Rio 24503, male; 24502, female, floriferous; 24501, fructiferous); collected also at S. Paulo de Olivença (Herb. Jard. Bot. Rio 24504, fructiferous). The ripe fruits are 2–3 cm long and ellipsoid; their pericarp is thick, fleshy-coriaceous, glabrous, more or less twisted and roughly rugose when dry; the laciniate arilloid is purplish. The fruits do not attain the dimensions given for this species in Warburg's monograph; perhaps they are variable in size. I have not seen typical material of *V. carinata* but only a specimen of Spruce's No. 3206, distributed by its collector under the name *V. hypoleuca,* which is incorporated by Warburg in *V. carinata.* We must consult the great European herbaria to settle this question.

I refer to this species No. 11265 (fructiferous only) of the Herb. Amaz. Mus. Pará, from the Middle Trombetas, and the male plant Herb. Jard. Bot. Rio 21203, from Faro at the western limit of the State of Pará. The latter differs from the others by its smaller leaves with more acute base, nearly as in *V. surinamensis;* the tomentum is faint; the inflorescences, however, are as in *V. carinata.*

Virola elliptica A. C. Smith from the Upper Rio Machado, northwestern Matto Grosso, differs from *V. carinata*, according to the description, specially in having the fruits twice as long as broad (30 mm ×16 mm); the fruit of *V. carinata* would be, according to the same botanist, nearly globose and smaller. The male plant is, however, unknown.

The Peruvian species *V. weberbaueri* Mgf. (which I have not seen) is allied to *V. carinata*, according to the author, but to me it seems more like *V. albidiflora*, because of its large leaves with more numerous secondary ribs. But its very faint tomentum at once distinguishes it from that.

13. **Virola albidiflora** Ducke, n. sp. Arbor magna (circa 30 m) ramulis modice crassis plus minus tetragonis et sulcatis, novellis dense ferrugineo-tomentosis, vetustioribus subglabris. Foliorum petiolus 8–10 mm longus, crassus, tomentosus, vulgo fortiter canaliculatus; lamina saepius 15–25 cm longa et 4–6 cm lata, rarius usque ad 30 cm longa et ad 8 cm lata, in maioribus et medianis oblongo-lanceolata marginibus parallelis, in minoribus oblonga marginibus arcuatis, basi obtusa et complicata rarius anguste rotundata vel subcordata, apice brevissime acuminata vel acuta, margine in vetustioribus saepe revoluta, sat crasse herbaceo-coriacea fragilis, in adultis supra praeter costam tomentosam glabra, sub-opaca, in vetustis vulgo rugulosa, subtus dense et persistenter molliter canoferrugineo-pilosa sericeomicans, costa mediana supra plana subtus crasse convexa, costis lateralibus utrinque 28–35 supra immersis subtus valde prominentibus margine arcuato-conjunctis, venulis supra immersis subtus pilositate occultis. Inflorescentiae ad axillas superiores; masculae saepius ad 15 rarius 20 cm longae multiramosae, pedunculo et ramis primariis validis, undique et flores extus dense canotomentosae, bracteis latis tenuiter canosericeis ante anthesin caducis, florum fasciculis anthesi circa 5–7 mm latis, pedicellis et floribus vix ad 1 mm longis; flores albidi perigonio infundibuliformi ad medium trifido lobis rotundatis, intus glabro, antheris 3 connatis apice obtusis quam columna glabra distincte brevioribus et latioribus. Inflorescentiae femineae floriferae ignotae; fructiferae masculis multo breviores, pedunculo rhachidibus et pedicellis (his brevissimis) crassis, fructibus maturis 3–4 cm longis et circa 20 mm latis ellipsoideis glabris, pericarpio crasso carnoso-coriaceo siccitate irregulariter rugoso et saepe torto, semine longitudinaliter sulcato arillodio purpureo praeter basin laciniato.

Habitat in civitate Amazonas, silvis non inundatis secus ripas paludosas rivulorum, leg. A. Ducke prope São Paulo de Olivença, florif. 3-10-1931, Herb. Jard. Bot. Rio 24563 (mas), fructibus maturis 25-2-1932, Herb. Jard. Bot. Rio 24564; circa Manáos (versus Marapatá) florif. 31-8-1931, Herb. Jard. Bot. Rio 24562 (mas). Specimina 24563 a 24562 differunt columna androecei longiore et graciliore, caeterum non distinguenda.

This species has a certain affinity with *V. carinata*, but its leaves are very much larger, with more numerous nerves, and are densely tomentose beneath; its whitish staminate flowers are much smaller. The fruits differ from those of *V. carinata* only in size; they are among the largest of the genus.

14. **Virola minutiflora** Ducke, n. sp. Arbor sat magna, innovationibus tenuiter rufotomentosis, ramulis cito subglabris modice crassis obsolete quadrangulis fortiter rugoso-striatis. Foliorum petiolus 8–12 mm longus, modice robustus, parum canaliculatus, rugosus, subglaber; lamina 8–15 cm

longa et 3–5 cm lata, obovato-oblonga, basin versus vulgo sat longe cuneata, basi ipsa anguste cordata vel rotundata rarius obtusa, marginibus lateralibus arcuatis, apice breviter subabrupte acuminata, subcoriacea, parum discolor, supra parum subtus vix nitidula, adulta supra praeter costam medianam (immersam, tenuiter tomentosam) glabra, subtus tomento minutissimo pallido induta et pilis stellatis ferrugineis maioribus punctulata, costa mediana subtus crasse prominente, costis lateralibus (utrinque 30–38) in pagina superiore impressis, in inferiore prominentibus ante marginem evanescentibus, venulis nullis vel obsoletissimis. Inflorescentiae masculae (solae notae) e ramulis novellis infra folia nondum evoluta, 2 vel 4 per ramulum, vix usque ad 7 cm longae, pauciramosae, rufotomentosae, florum fasciculis 3–5 mm in diametro, multifloris, densissimis, ante anthesin bracteis latis medio acutis parum tomentellis involucratis, floribus ferrugineis, pedicello vix ad 1 mm longo, perigonio 0.6–0.8 mm longo infundibuliformi ad medium trifido extus tomentoso, antheris 3 connatis sublinearibus subacutiusculis quam columna gracilii glabra aliquanto brevioribus et latioribus. Arbor feminea ignota.

Habitat circa Manáos (civitate Amazonas), silva non inundabili, leg. A. Ducke loco Cachoeira Grande 8-8-1929 (Herb. Jard. Bot. Rio 24559), et circa locum Villa Belisario 31-8-1931 (Herb. Jard. Bot. Rio 24560).

This new species seems to occupy an intermediate place between *V. rugulosa* and *V. venosa*, but differs from both by more numerous leaf-nerves. The inflorescences are inserted on the basal part of the young branchlets, under the as yet undeveloped leaves, whereas the old branches often lose their foliage. It differs from the other species with very numerous leaf-nerves by the smaller leaves and inflorescences, by the relatively faint tomentum, and by the exceedingly small flowers (the smallest of the genus).

15. **Virola crebrinervia** Ducke, n. sp. Arbor sat magna innovationibus fugaciter canoferrugineo-tomentosis, ramulis modice robustis obsolete quadrangulis cito subglabris. Foliorum petiolus 5–7 mm longus modice robustus late et profunde canaliculatus, tomentosus, tardius plus minus glabratus; lamina 10–18 cm longa et 2.2–3 cm lata, anguste oblongo-lanceolata marginibus subparallelis, basi vulgo distinctissime cordata, apice subsensim brevius vel longius vulgo acutissime caudato-acuminata, membranacea, utrinque cito glabra, supra fuscescens subtus ferruginescens, supra parum subtus vix nitidula, costa mediana subtus sat crassa, costis lateralibus in utroque latere 50–56 subtus tenuiter at distincte prominentibus, parum ante marginem arcuato-anastomosantibus, venulis utrinque sub lente tenuiter reticulatis. Inflorescentiae masculae (solae notae) in ramulo infra folia ut videtur vulgo duae, ad 13 cm longae, sat floribundae, canoferrugineo-tomentosae, florum fasciculis 3–5 mm diametro multifloris densis ante anthesin bractea lata dense tomentella involucratis; flores pedicello vix ad 1 mm longo, perigonio vix ad 1.5 mm longo anthesi infundibuliformi ad medium trifido extus tomentoso, antheris 3 connatis sublinearibus connectivo brevissime apiculatis quam columna gracili glabra aliquanto brevioribus et latioribus. Arbor feminea ignota.

Habitat prope Gurupá (in civitate Pará), silva humidissima non inundabili 10-8-1918 leg. A. Ducke (Herb. Amaz. Mus. Pará 17182).

This belongs to a group of four species characterized by the presence of 50 to 60 pairs of lateral leaf-ribs. It is distinguished from the three others

(*V. multicostata*, *V. multinervia*, and *V. decorticans*) by the narrow lanceolate leaves with nearly parallel sides (as in *V. surinamensis* and others). It has also a certain affinity with *V. minutiflora*, but differs in the form of the leaves and in their much more numerous ribs.

16. **Virola multicostata** Ducke, n.sp. Arbor elata ramulis crassis fortiter rugosis, partibus vegetativis solum vetustis visis glabratis. Foliorum petiolus 10–12 mm longus sat robustus vix canaliculatus; lamina 20–28 cm longa, 7–9.5 cm lata, oblonga, basi subcordata apice breviter abrupte acuminata, chartacea, costis utrinque 50–60 supra immersis subtus fortiter prominentibus parum ante marginem arcuato-anastomosantibus. Inflorescentiae masculae circa 15 cm longae ramosae floribundae, undique canotomentosae, florum fasciculis 3–5 mm diametro, densis, multifloris, floribus vix ad 1 mm pedicellatis, perigonio 1 mm parum longiore anthesi infundibuliformi ad medium trifido, extus dense tomentoso, antheris 3 connatis sublinearibus connectivo brevissime apiculato columnae gracili subaequilongis at magis latis. Arbor feminea ignota.
Habitat in regione Rio Branco de Obidos (in civitate Pará) loco Castanhal Grande silva non inundabili, 27-12-1913 leg. A. Ducke (Herb. Amaz. Mus. Pará 15257).

This species belongs to a group remarkable for the very great number of lateral leaf-ribs, viz. *V. multinervia*, *V. decorticans*, and *V. crebrinervia*. It differs from *V. multinervia* by the smaller and nearly parallel-sided leaves, the scarcely visible reticulate veins, and the inflorescences covered with a tomentum of much shorter hairs, which cover also the perigonia; from the two other mentioned species, by its very different leaves and many other characters. Unfortunately we have only very incomplete herbarium material of this species: a branchlet, some old leaves, and some male inflorescences, all of them gathered under the tree. I publish a description because I suppose we may always recognize this species on the basis of leaf characters.

17. **Virola multinervia** Ducke, n.sp. Arbor vulgo sat magna (20–30 m), ramulis subtetragonis, annotinis densissime fulvovillosis, hornotinis glabris crassis. Foliorum petiolus 5–10 mm longus crassus dense fulvotomentosus, supra canaliculatus; lamina vulgo 20–40 cm longa et 8–14 cm lata, obovato-vel ovato-oblonga, basi saepissime sat angusta plus minus cordata, apice abrupte caudato-acuminata acumine saepius brevi et falcato, subcoriacea, parum discolor, adulta supra praeter costam glabra subtus dense et longe canescenti-stellatopilosa, utrinque opaca vel praesertim supra plus minus nitida, costa mediana in utraque pagina dense cano-vel fulvo-villosa, subtus crassius prominente, costis lateralibus (utrinque 45–58, saepe fere horizontalibus) et venulis transversis supra impressis subtus prominentibus, costis prope marginem reticulato-anastomosantibus minus distincte arcuato-conjunctis. Inflorescentiae 2 e ramuli annotini parte basali infra folia, rhachidibus dense fulvovillosis. Inflorescentiae masculinae vulgo ultra 20 cm longae, multiramosae, ramulis ultimis gracilibus, bracteis late ovatis medio acuminatis tenuiter tomentosis 5–6 mm longis et latis, anthesi caducis, florum fasciculis multifloris diametro 5–6 mm, pedicellis 1–2 mm longis tenuissimis longe et sat sparsim pilosis; flores albi, siccitate fusci, perigonio 1–1.5 mm longo infundibuliformi ad medium trifido apice extus et praesertim ad margines longe et parce piloso, antheris 3 (an semper?) connatis linearibus

apice acutiusculis, quam columna gracili glabra parum brevioribus et latioribus. Inflorescentiae femininae quam masculae breviores (non ultra 15 cm longae), rhachidibus robustioribus minus ramosis, bracteis et floribus aliquanto maioribus, his crassioribus extus dense tomentosis, fulvis, pedicello crasso brevissimo; ovarium dense rufotomentosum stylo glabro. Fructus adultus circa 2.5–3 cm longus et circa 2 cm crassus, oblongo-elliptico-subobovatus, breviter crasse pedicellatus, pilis 0.5–1.5 mm longis ramulis brevissimis alternis munitis post maturitatem persistentibus dense rufo-fulvo-subhispido-velutinus, pericarpio crasso, semine longitudinaliter sulcato arillodio laciniato purpureo.

Habitat non infrequens in silvis non inundatis circa Manáos (civ. Amazonas), loco Estrada do Aleixo legit A. Ducke: arbor feminea florifera 15-5-1932, fructibus maturis 9–12 (cum ligni numero 100), Herb. Jard. Bot. Rio 24555; arbor mascula florifera 16-5-1933, Herb. Jard. Bot. Rio 24556. Ad ipsam speciem evidenter pertinent specimina fructifera a J. G. Kuhlmann lecta in Peruvia orientali prope Yurimaguas, typo similia at petiolis longioribus (ad 18 mm), foliis basi profundius cordatis apice vix caudato-acuminatis, pilositate aliquanto breviore (Herb. Jard. Bot. Rio 24557).

This beautiful species is not rare in the upland virgin rain-forests north of Manáos; it has been collected also in eastern Peru. It is remarkable for the large leaves with very numerous lateral ribs recalling only those of *V. decorticans*. The male inflorescence resembles that of *V. rugulosa* Warb. (Upper Rio Negro), the leaves of which have, however, much fewer nerves, as also in the allied *V. mycetis* Pulle, of Surinam.

18. **Virola decorticans** Ducke, n.sp. Arbor mediocris. Ramuli subcompressi, ut in variis generis *Vochysia* speciebus in laminas magnas decorticantes, cortice dense rufovelutino, hornotini crassi, apice ramulum annotinum foliosum et inflorescentiam gerentes ibique tegumentis magnis foliaceis persistentibus e gemmis oriundis involuti. Foliorum petiolus 1–2 cm longus robustissimus dense rufovelutinus supra leviter canaliculatus, lamina in speciminibus nostris 52–60 cm longa, 15–21 cm lata, oblongo-obovata basin versus longe cuneata, basi anguste cordata vel rotundata, apice abrupte caudato-acuminata acumine longe subulato, herbaceo-coriacea, supra glaucescens subnitida, subtus ferruginea opaca, costa mediana in utraque pagina rufovelutina subtus valde crassa, costis literalibus (utrinque 52–56) et venulis transversis supra immersis subtus prominentibus, costis margine arcuatim conjunctis, pilis stellatis pro genere longis in utraque pagina persistentibus, in superiore magis dispersis, in inferiore praesertim in nervis et venulis densioribus. Inflorescentia feminea solum fructifera nota, ex apice rami hornotini ad basin ramuli annotini foliiferi oriunda, 12–16 cm longa, pauciramosa, pedunculo et rhachidibus robustis dense rufovelutinis, bracteis nonnullis persistentibus 6–15 mm longis oblongo-vel ovato-lanceolatis utrinque tenuiter canosericeis; fructus (ut videtur adultus) oblongo-ovatus vel ellipsoideus 2.5–3.5 cm longus 1.8–2.2 cm latus, vix brevissime pedicellatus, pilis 2–2.5 mm longis alterne brevissime spinuloso-ramosis persistentibus dense rufo-subhispido-velutinus. Inflorescentia mascula quam feminea maior ampla multiramosa, rhachide et ramulis tenuibus dense rufovillosis pilis spinulosis, bracteis ovatis vulgo acutis utrinque rufotomentosis, 6–10 mm longis, anthesi persistentibus, florum fasciculis multifloris diametro 6–10 mm, pedicellis 1–3 mm longis tenuibus longiuscule et sat dense pilosis; flores siccitate ferruginei perigonio 1–2 mm longo anthesi anguste infundibuliformi

fere ad basin trifido extus et ad margines densiuscule sat breviter piloso, antheris 3 connatis linearibus apice acutiusculis quam columna gracili distincte latioribus at vix longioribus.

Habitat prope São Paulo de Olivença (Rio Solimões, in civitate Amazonas), silva humida non inundabili prope rivum Jaratuba, planta feminea, leg. A. Ducke 4-11-1927, Herb. Jard. Bot. Rio 19571; in Peruvia orientali: Victoria, Rio Amazonas, Depart. Loreto, L. Williams 3077, planta mascula (sub nomine *V. mollissima* distributa, inflorescentiam solam vidi).

This magnificent species cannot be mistaken with any other, because of the deciduous cortex of the branchlets and the enormous leaves, hairy on both sides. The very numerous lateral leaf-ribs and the fruit covered with hispid-velvety spur-ramified persistent hairs recall *V. multinervia.*

19. VIROLA CALOPHYLLA Spruce ex Warb. This species can be confused only with *V. calophylloidea* Mgf., from which it differs in the much larger leaves and inflorescences, the more ferruginous tomentum, and certain other less important characters; the fruit is a little more ellipsoid, very finely granulose-rugose. The tree, commonly of a middle size, grows in the upland virgin forest of the western and central parts of the Amazonian plain, from the Middle Tapajoz to Iquitos, Eastern Peru. Our specimens come from the Tapajoz river near the lowest cataracts (Herb. Jard. Bot. Rio 18632, male), from the environs of the lake José-Assú near Parintins (Herb. Jard. Bot. Rio 24487, male), from the Rio Purús near the mouth of the Rio Acre (Herb. Jard. Bot. Rio 24486, male), and from S. Paulo de Olvença (Herb. Jard. Bot. Rio 24494, male, and 24485, fructiferous). I have also seen a male specimen from Seringal S. Francisco, Territory of Acre (*Ule* 9376). The type is from the Upper Rio Negro.

20. VIROLA CALOPHYLLOIDEA Mgf. This species is allied to *V. calophylla* but differs constantly by its smaller leaves (not exceeding 35 cm by 8 cm), often oblong-lanceolate with rounded or obtuse base (rarely cordate) and with longer acuminate apex, having 12–18 (more frequently 15 or 16) pairs of secondary ribs; by the brownish red rather than ferruginous tomentum of the inflorescences, flowers, and fruits; by the short (1.5–3.5 cm) male inflorescences; by the very short and poor female inflorescences, which nearly lack a common peduncle; by the more clavate staminate flowers, only trilobate in their terminal quarter; by the androecium column distinctly longer than the anthers and in its superior third suddenly narrowed in the form of a cylindric neck. The fruits, in our specimens, are more obovate, with still finer rugosities than in the specimens of *V. calophylla* in our collection, but I do not know whether this difference is constant; they are 1.5–2 cm long and 1 cm broad below the apex, very finely rugose, densely tomentose with microscopic stellate hairs persisting after maturity; their pericarp is not very thick but is rigid; the scarlet arilloid is laciniate, except at the base.

This small tree is not very rare in the undergrowth of the upland virgin forests near Manáos, but has not yet been gathered elsewhere. Our herbarium specimens come from the forests along the "Estrada do Aleixo"

(Herb. Jard. Bot. Rio 24539, male) and northeast of Flores (Herb. Jard. Bot. Rio 24540, female). I have compared them with a cotype (*Ule* 8846).

21. **Virola parvifolia** Ducke, n.sp. Arbor mediocris, ramulis sat tenuibus glabris longitudinaliter striatis et distincte rugoso-tuberculatis, obscure rufis demum atrofuscis. Folia petiolo 6–14 mm longo robusto glabro, tuberculato, supra plus minus canaliculato; lamina vulgo 5–10 (rarius 3–5 vel 10–11) cm longa et 3–5 cm lata, ovato-elliptica, basi obtusa, apice obtusa vel saepius brevissime late et obtuse acuminata et retusiuscula, margine tenuiter revoluto subtus lineiformi-elevato, coriacea, solum novissima fugaciter tomentosa cito glabra, vix discolor, supra nitida subtus opaca, in utraque pagina sub lente dense minute tuberculato-granulata, costa mediana supra impressa subtus prominente, costis secundariis utrinque 12–16 parallelis vix curvatis in utraque pagina tenuissimis vel subobsoletis ante marginem evanescentibus. Inflorescentiae masculae (solae notae) in axillis superioribus, folia excedentes, usque ad 120 mm longae, longe pedunculatae, pauciramosae, rhachidibus tuberculatis glabris solum partibus novissimis fugaciter puberulis, bracteis caducissimis non visis, fleorum fasciculis paucis dissitis diametro 5–7 mm, pedicellis gracilibus ad 2 mm longis canotomentellis. Flores ferruginei, 1.5–2 mm longi, infundibuliformes, ad medium trifidi, extus tenuiter canopuberuli, intus glabri tenuissime rugulosi; staminum columna glabra, gracilis medio parum incrassata, quam antherae (tres in floribus examinatis, apice subobtusae) multo longior iisque subaequilata. Planta feminea ignota.

Habitat in silvis humilioribus solo humo-silicoso, "catingas" dictis, prope Camanáos (Rio Negro superiore, in civitate Amazonas), 12-10-1932 leg. A. Ducke (Herb. Jard. Bot. Rio 24553).

This new species occupies an isolated position with the genus. The small glabrous leaves and their peculiar nervation, the relatively long but few branched and nearly glabrous inflorescences, and the small granules or tubercles, numerous and very conspicuous on the branchlets, leaves, and peduncles, are characteristics which preclude mistaking this for any other species.

Obituary

DR. WILLIAM HOLLAND WILMER, distinguished ophthalmologist and for many years a member of the Washington Academy of Sciences, died suddenly at his home on March 12, 1936. The son of the Right Reverend Richard Hooker and Margaret (Brown) Wilmer, he was born in Powhatan County, Va., August 26, 1863.

His preliminary education was received at the Episcopal High School, Alexandria, Va., and he was graduated in medicine from the University of Virginia in 1885. His post-graduate training was at Mt. Sinai Hospital, New York; at the New York Polyclinic and at various hospitals in Europe.

Dr. Wilmer thereafter served as assistant to the late Dr. Emil Gruening until 1889 when he commenced private practice in Washington. In 1891 he married Miss Re Lewis Smith of Pennsylvania.

In Washington Dr. Wilmer rapidly became the leading ophthalmologist and his skill, united with his gracious personal qualities, attracted to him patients from the entire country, particularly the South. During the first period of Washington residence, he was an active member of the staff of the Episcopal Eye, Ear and Throat Hospital and consulting ophthalmologist on the staffs of a number of the general hospitals. In 1906 he became Professor of Ophthalmology at the Georgetown University School of Medicine.

In 1911 Dr. Wilmer was commissioned a lieutenant in the Medical Reserve Corps, U. S. Army, and at the beginning of the World War he was promoted to major and placed at the head of the Medical Research Laboratory of the Air Service at Mineola, L. I. His work there proved so valuable that he was, at General Pershing's request, sent to France where he carried forward similar researches for the A. E. F. He was awarded the Distinguished Service Medal in 1919 and relinquished his connection with the army with the rank of Brigadier General. In 1924 he was decorated with the cross of the Legion of Honor of France.

Dr. Wilmer resumed his private work in Washington after the war, but in 1925 he went to Baltimore to become Director of the Wilmer Institute of Ophthalmology, a research unit of the Johns Hopkins Hospital, which was created as a tribute to him largely by the gifts of his patients and friends. In addition to the directorship of the Institute, he was Professor of Ophthalmology of the Johns Hopkins Medical School and ophthalmologist in chief of the Johns Hopkins Hospital. He retired from these positions in 1934 and returned to his earlier home and work in Washington.

Dr. Wilmer was a frequent contributor to the periodic literature on ophthalmology, but his outstanding publication is *The atlas fundus oculi*, a beautiful volume with 100 colored plates. He was a member and past president of the American Ophthalmological Society; a director of the National Committee for the Prevention of Blindness; a member of the Advisory Committee for the Prevention of Hereditary Blindness; of the National Institute of Social Science; of the National Committee on Mental Hygiene; of the American Association for the Advancement of Science; a Fellow of the American Medical Association; a founder and Fellow of the American College of Surgeons; a member of the Medical Society of the District of Columbia; of the Southern Medical Association; of the Army and Navy Air Service Association; of the Medical Air Service Association; of the Association of Military Surgeons of the U. S. He was also an honorary member of the Oxford Ophthalmological Society of England; of the Hungarian Ophthalmological Society; of the Chicago Ophthalmological Society; and of the

Saranac Medical Society. He was given honorary degrees by Georgetown, Princeton, New York, and Johns Hopkins Universities.

August Frederick Foerste, associate in paleontology at the U. S. National Museum since 1932, died April 23, 1936, at the home of relatives at Dayton, Ohio. Doctor Foerste was born May 7, 1862, at Dayton, Ohio. He received the A.B. degree in 1887 and the Sc.D. degree in 1927 from Denison University; the A.M. in 1888 and Ph.D. in 1890 from Harvard University. From 1890 to 1892 he studied petrography at Heidelberg and Paris.

Doctor Foerste's vocation was the teaching of physics from 1893 to 1932 at the Steele High School, Dayton, Ohio. His avocation in the meantime was research in paleontology in which capacity at one time or other he was employed by the U. S. Geological Survey, Canadian Geological Survey, and the Indiana, Kentucky, and Ohio State Surveys. He became a distinguished authority on Ordovician and Silurian faunas with which his numerous publications largely deal. Upon retirement from teaching in 1932 he came to the National Museum as an associate in paleontology and devoted his time and energy to the preparation of a monograph on early Paleozoic cephalopods.

Doctor Foerste was a member of the Geological Society of America; the Paleontological Society of America, of which he was the president in 1928; the American Association for the Advancement of Science; the Ohio Academy of Science, of which he was the president in 1931; Washington Academy of Sciences; and he was one of the two honorary members of the Engineers' Club of Dayton, the other being Wilbur Wright. He was the representative of the Paleontological Society of America to the National Research Council.

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PHYSICS.—*Electrical messages from the earth: their reception and interpretation.*[1] O. H. Gish, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

Electrical messages were first received from the earth early in the last century. Joseph Henry in America and Michael Faraday in England had made their notable discovery of electromagnetic induction about a decade and a half before. S. F. B. Morse, just 100 years ago, had invented the first practical telegraph. Then nine years later, in 1844, the first commercial telegraph-system was put in operation between New York, and Washington. In the next few years similar systems sprang up in various parts of the world. When sending messages on these systems there occasionally appeared other signals which sometimes became so frequent and intense as to seriously interfere with the sending of telegrams. A visitation of these intruding signals was usually widespread, coming at about the same time and running much the same course everywhere. Close observation of the signals which intruded on the lines of the British system led W. H. Barlow to conclude in 1847 that they come from the earth, that such signals may be received at any time, but that they are usually not intense enough to interfere with the telegraph-service. When submarine cables came into use, disturbing signals were also noted on them at the same time as the great disturbances on land lines. Disturbances of this sort were accompanied by erratic agitation of the compass-needle, and frequently by unusual displays of polar lights. These intruding signals constitute the electric messages from the earth which are the theme of this paper.

It was soon recognized that these signals resulted from electric currents of some natural origin which circulate in the earth, branch through telegraph-lines, and, when intense enough, actuate the receiving instruments and sometimes even damage them. The occasions when the electric earth-currents are intense and unusually agitated are termed storms, earth-current storms, not because of any connec-

[1] Address of the retiring president, delivered before the Philosophical Society of Washington, January 4, 1936. Received April 3, 1936.

tion with weather, for there is none, but rather for about the same reason that an emotional outburst is so designated.

One of the more intense of these storms occurred in 1859. All the grounded telegraph-lines of the world were apparently affected by that storm. During most of a seven-day period from August 29 to September 4 it was impossible to send telegrams. However, occasionally these currents were sufficiently intense and so steady that they could be used instead of the usual batteries for operating the telegraph-instruments. On September 2, the line from Portland, Maine, to Boston, Massachusetts, spanning a distance of 110 miles, was *worked* by the earth-currents alone, commercial messages being sent from 8 to 10 a.m. The line between Fall River and South Braintree, Massachusetts, a distance of 40 miles, was also worked in the same way. A message was also sent in this manner between Philadelphia and Pittsburgh. In some cases the strength of the current during this storm was roughly determined. Thus it was reported that on one line in France, which spanned a distance of 600 km the current "was equal to that produced by a battery of 800 volts." In Norway the disturbance to the telegraph was said to have been greater than in other parts of Europe. During this electric commotion the compass-needle was everywhere visibly agitated. At Rome it changed direction 4° 13′ in a half hour and the horizontal magnetic force changed by one-eighth its whole value. Extraordinary displays of polar lights were also reported. The aurora borealis was seen as far south as 18° north latitude and at higher latitudes the brilliance of these lights was said to "nearly equal the light of the full moon." Except for the unusual duration and intensity of this storm and the accompanying magnetic and auroral manifestations, this description would apply to many other similar events. The association of the aurora borealis with such disturbances to the telegraph-service has been noted by telegraph operators in some parts of the United States who refer to such an event as an *aurora on the line.* However, the relationship is not as direct as that expression would imply.

These impulsive electric messages, which signalize earth-current storms, come only a relatively small part of the time, on the average about 16 days a year. The rest of the time electric messages of a quite different type may be received—messages of a more tranquil nature which are patiently repeated day after day, year after year. However, the electric currents which convey them are so weak that some care is required to receive them without such distortion as may lead to misinterpretation. Because some aspects of the method of receiving

O. H. Gish
President, Philosophical Society of Washington
1935

these messages have important bearing on their interpretation, it seems appropriate to describe here some of the essential features of what in technical parlance is called an earth-current measuring system.

It was early recognized that systematic observations were required for satisfactorily investigating these phenomena. The telegraph-systems by means of which the first evidence for the existence of earth-currents was obtained suggested the gross features of the arrangements used, even up to the present time. The first continuous registration of earth-currents was begun at Greenwich Observatory in 1865 under the direction of Astronomer Royal G. B. Airy. The arrangement may be described as two special telegraph-lines, with the two ends of each line connected to earth and with a galvanometer substituted for each of the telegraph-receivers. One of these lines extended from the Observatory eastward to Dartford, a distance of 9.76 miles; the other from the Observatory southward to Croydon, a distance of 8 miles. The contact to earth was made by soldering the wires to water-pipes. The deflections of the galvanometers were registered photographically. From the two components thus registered the direction of the earth-current and the intensity of the impelling force, the potential gradient, was determined. To the casual observer this system would seem equivalent to the most carefully installed modern one (the gross features of such being suggested by Fig. 1) but the reliability of the results obtained from the two different systems may not be at all comparable. The basis for this statement shall be indicated shortly.

Systematic observation of earth-currents was apparently stimulated by recommendations made by the Electrical Congress which met in Paris in 1881. Soon after this observations were started in France, Germany, Norway, Finland, Russia, Italy, and Bulgaria. Bachmetjew, in Bulgaria, used small spans, 80 to 200 meters in length. The longest spans were those in Germany where the Earth-current Committee used two underground telegraph-cables—one extending from Berlin southward to Dresden, a distance of 120 km, the other extending from Berlin eastward to Thorn, a distance of 262 km. Registration at Berlin began in 1883 and was continued until 1891. The records for the first five years were evaluated and analyzed by Weinstein, whose report stood as the outstanding contribution to the subject for several decades. In 1910 such observations were started at the Ebro Observatory, near Tortosa, Spain, where they have been continued with but little interruption up to the present time, thus

providing a body of data of much value. The net outcome of all these endeavors, as it appeared about a decade ago, may be summed up figuratively as follows: The impulsive messages received at these dif-

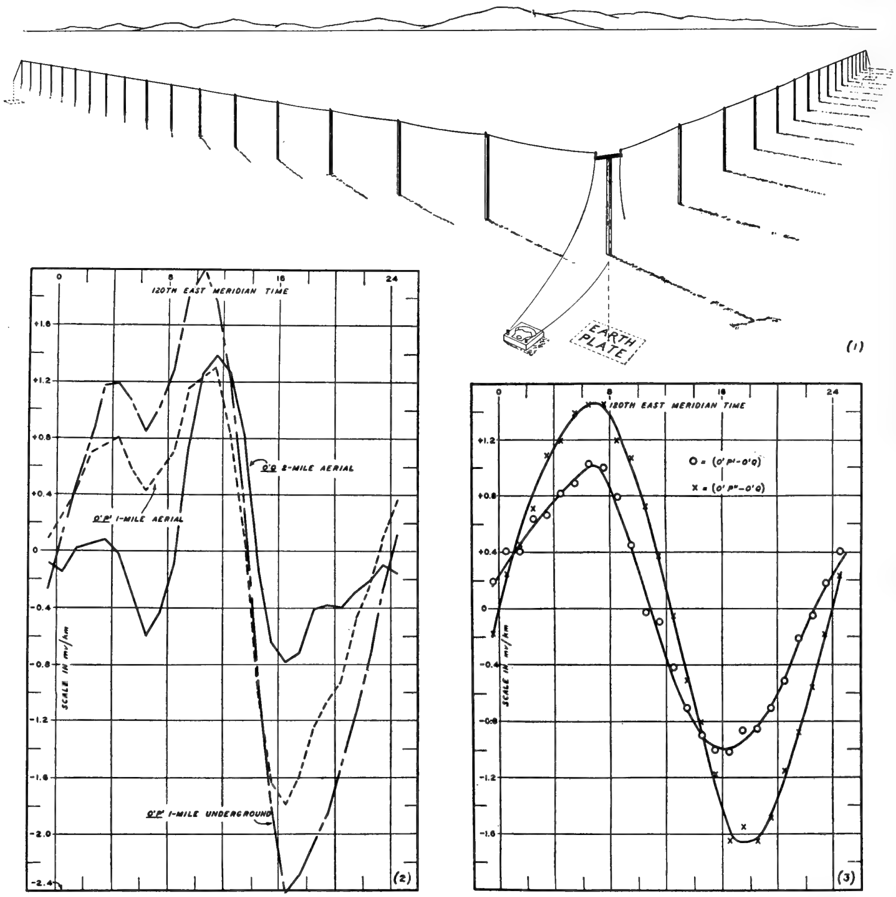

Fig. 1.—The receiving *antennae.* The conspicuous part of a simple arrangement for *receiving electrical messages* from the earth resembles two telegraph-lines which extend in different directions. These lines serve only to connect the pairs of earthed points with instruments which register the difference of potential between pairs of points.
Fig. 2.—Inconsistent *messages.* These *messages* which were received at Watheroo, January 1927, are shown here for the purpose of stressing the thesis that considerable care is required in order to receive the signals, or to record the potentials, without thereby introducing an irrelevant part which may hopelessly complicate interpretation.
Fig. 3.—Avoidable irrelevant *messages.* The inconsistent parts of the variation in the apparent gradients shown in Fig. 2 are represented in these graphs.

ferent places conveyed a fairly consistent story but the more tranquil messages were not in general agreement, only those received at Berlin and those received at the Ebro Observatory being in fair accord.[2]

[2] General references: (*a*) J. Bosler, *Les courants telluriques, Traité d'électricité atmosphérique et tellurique, publié sous la direction de E. Mathias,* 453–498 (1924); (*b*)

Such was the status in 1922 when the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in order to further its program for investigating the electrical and magnetic phenomena of the earth, installed an earth-current measuring system at its magnetic observatory near Watheroo, Western Australia.[3,4] Since then this activity of the Department has been extended, first by establishing another system at its observatory near Huancayo, Peru, in 1925.[5] Later through cooperation with the United States Coast and Geodetic Survey and the American Telephone and Telegraph Company the registration of earth-currents was begun in 1931 at the Coast and Geodetic Survey magnetic observatory near Tucson, Arizona.[6] Registrations were also obtained at College, Alaska, from August 1932 to June 1934, through cooperation with the United States Coast and Geodetic Survey and the University of Alaska,[7] and at Chesterfield, Inlet, Canada, through cooperation with the Meteorological Service of Canada.[8] The data from the two latter stations are of special significance because these places are both close to the Arctic Circle and because these projects were a part of that remarkable international cooperative program known as the Second International Polar Year. Telephone and telegraph organizations have naturally been interested in these electric currents for a long time, but as a rule they have made no extended investigation of this class of phenomena. However, the Bell Telephone Laboratories have made a notable exception to the rule by conducting registrations of earth-currents during recent years at a number of places in the United States.[9] Some systematic meas- ure ments have also been made during the past decade in Sweden.[10] Dr. G. C. Southworth of the Bell Telephone Laboratories, in consultation with members of the Department of Terrestrial Magnetism, planned

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J. E. BURBANK, Terr. Mag., **10**: 23–49 (1905); (*c*) A. NIPPOLDT, *Erdmagnetismus, Erdstrom, und Polarlicht, Sammlung Göschen* No. 175 (1921); (*d*) J. BARTELS, *Handbuch der Experimentalphysik*, **25**:*I*, 645–647 (1928); (*e*) B. Gutenberg, *Lehrbuch der Geophysik*, 429–433 (1929); (*f*) *Earth-currents*, Encyc. Brit., 14th ed., **7**: 837–841 (1929); (*g*) O. H. GISH, *Natural electric currents in the Earth's crust*, Sci. Mon., **32**: 5–21 (1931); (*h*) O. H. GISH, *Les courants électriques naturels de l'écorce de la Terre et leur rapport avec le magnétisme terrestre*, Cong. Internat. d'Electricité, Paris, 11e Sec., Comm. No. 1-C-2 (1932).

References (*a*) and (*b*) contain thorough bibliographies up to the dates of their publication. Reference (*h*) cites original articles for the years 1925 to 1931, inclusive.

[3] O. H. GISH, Terr. Mag., **28**: 89–108. 1923.

[4] O. H. GISH and W. J. ROONEY, Terr. Mag., **33**: 79–90. 1928.

[5] O. H. GISH and W. J. ROONEY, Terr. Mag., **35**: 213–224. 1930.

[6] W. J. ROONEY, Terr. Mag., **40**: 183–192. 1935.

[7] W. J. ROONEY and K. L. SHERMAN, Terr. Mag., **39**: 187–199. 1934.

[8] B. W. CURRIE, Terr. Mag., **39**: 293–297. 1934.

[9] G. C. SOUTHWORTH, Terr. Mag., **40**: 237–254. 1935.

[10] D. STENQUIST, *Étude des courants telluriques Mém. Direction Gén. Télégr.*, Stockholm, Fasc. 1, (1925). Fasc. 2 (1930); Terr. Mag., **32**: 143–145 (1927), **33**: 205–209 (1928).

the program and devised the means by which long-distance telephone-lines could be used satisfactorily for this work without interfering with the use of the lines for telephone-service.

The tranquil messages received in these more recent endeavors are in reasonably good agreement among themselves and also with those obtained at Berlin and at the Ebro Observatory. This outcome instills confidence in the technique which has been developed for receiving them and enables one now to better grasp the broader significance of these messages.

The features of this technique which deserve mention here pertain to the elimination of distorting effects of local origin, especially those which depend upon the manner of making the electrical contact with the Earth. In the installation at Greenwich, it will be recalled, that was accomplished by soldering the connecting wires to water-pipes. Plates of metals or coils of wire have been variously used instead of the water-pipes. Sometimes these electrodes are surrounded by charcoal or clay obtained from a common source, or a metal is suspended in a solution of one of its salts, the whole being contained in a porous jar, which is imbedded in earth. These are some of the means used in an attempt to avoid the *battery-effect* which generally exists between two plates of metal or other material when placed in earth. Even when all practical precautions are exercised, these effects may still be great enough to introduce important error in measurements of the character here considered.

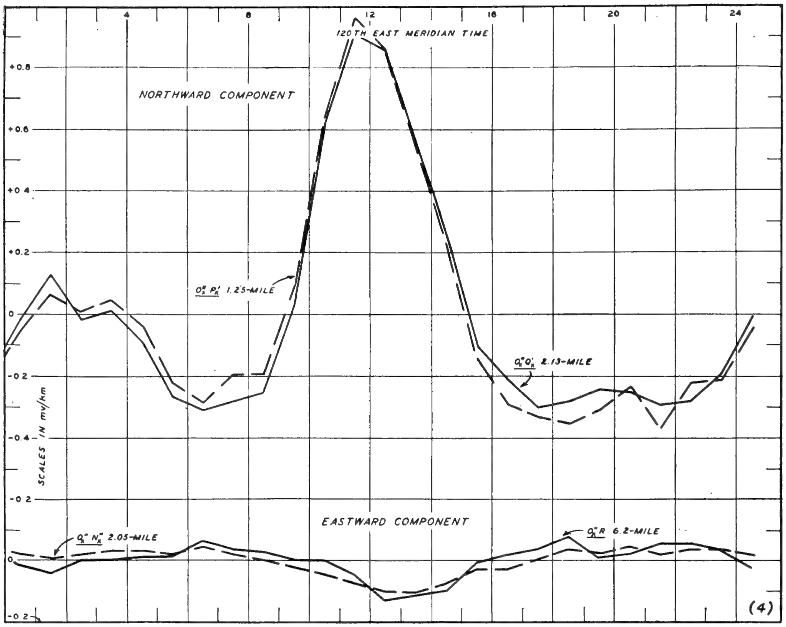
These contact electromotive forces or more briefly contact-potentials must be recognized for what they are and constantly kept in mind by investigators in order that interpretations be not confused by this extraneous feature. Although it has not been found possible to entirely eliminate such effects, yet it is feasible to control them within certain limits and to an extent such that their effect may not confuse the measurements of what seem to be the more important aspects of the true earth-currents. That this is possible has been clearly shown by results obtained at the Watheroo Magnetic Observatory.[11] There, as in all installations which have been made under the guidance of the Department of Terrestrial Magnetism, pure lead wire or tubing is used as the material for making the contact with earth. This in the form of a flat spiral, or web, is placed in the earth five or ten feet below the surface and compactly imbedded in clay,

[11] O. H. Gish, Carnegie Inst. Wash. Year Book 27, 253–254 (1928); also C. R. Assemblée de Prague, 1927, Union Géod, Geéophys. Internat., Sec. Mag. Electr. Terr., Bull. No. 7, 247 (1929).

which in some cases is carted to the place for that purpose. The wire which leads from this electrode to the conducting line is very carefully insulated from the surrounding earth so that the entire contact with earth is confined to the lead web at a depth where no appreciable short-time changes of temperature, humidity, soil-moisture, etc., occur, and where mechanical action resulting from operations on the surface can exercise only a minor influence on the electrode. However, even after all precautions are taken, the slowly changing environment of the electrode may give rise to conspicuous changes in the contact-potential of the electrodes. The net effect of these upon the data derived from the measurements may be reduced by placing the points of contact farther apart, thereby increasing the part contributed to a given measurement by the true earth-current without a corresponding increase in that extraneous effect which is brought forth by the electrodes.

The question may arise as to how these extraneous effects can be detected in the measurements or registrations. The answer to this calls for a description of another feature first used systematically at the Watheroo Magnetic Observatory and later at the Huancayo Magnetic Observatory. The points for contact with the earth at Watheroo were selected so as to lie on true north-south and true east-west lines, respectively. Two pairs of points for each of these directions are now in use there (earlier there were three). Their positions and the distances they span differ. Thus two independent records for each component of the earth-current gradient are obtained. If it is found by comparing these that the variations in the gradients are nearly equal, then it is almost certain that they are free from important spurious effects arising from the electrodes. For it is not to be expected that the conditions which give rise to variations in the electrode-potentials vary with position in just the manner required to yield the same variations in gradients derived from two different pairs of points which represent different spans on the earth. The potentials which characterize the earth-currents may, however, be expected to be such a function of position. Thus on the average one might expect the electrode-effects to be a smaller part of the measured gradient when the span between points is great. The nature of some spurious electrode-effects and the manner in which they may be detected are illustrated by graphs constructed from data obtained at Watheroo.[12] These, which appear in Fig. 2, show variations during the day which are different for three pairs of points so situated that they should yield the north-

[12] W. J. ROONEY, Terr. Mag. **37**: 363–374. 1932.



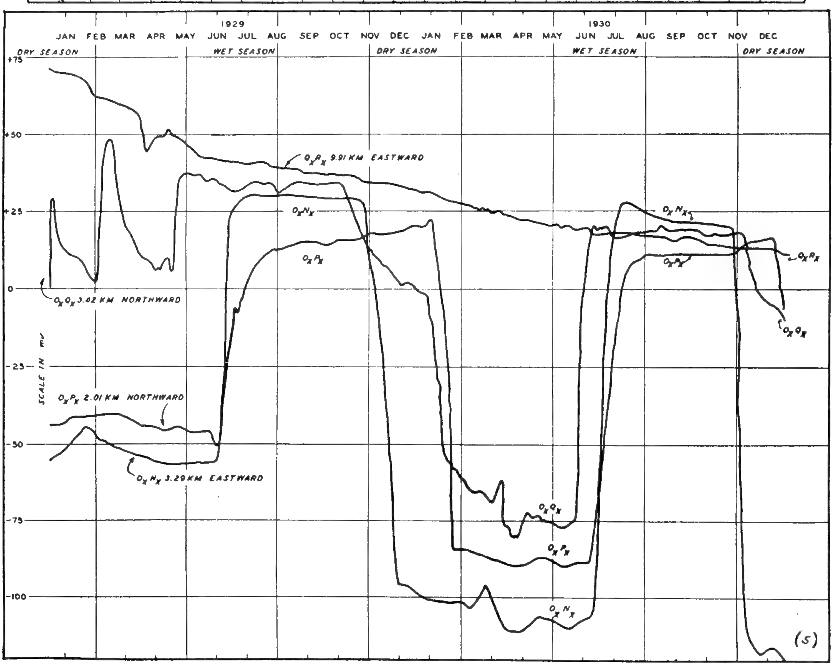


Fig. 4.—Consistent *messages.* These were obtained at Watheroo in December 1927 after improving the receiving system. They show that inconsistencies such as are exhibited in Fig. 3 may be avoided and a high degree of consistency realized when suitable care is exercised.

Fig. 5.—Unavoidable irrelevant *messages.* The daily means of potentials registered at Watheroo during 1929 and 1930, shown in these graphs, have no common characteristic such as should be noticeable if they were related to a general flow of electricity in the earth.

ward component of the earth-current gradient. Those drawn in broken lines are obtained between points one mile apart, whereas that drawn solid is for a span of two miles. Since in computing the gradients, here expressed in millivolts per kilometer, the measured differences of potential are divided by the distance between the points, any effect which may not depend on distance would tend to be less in the case of the longer span. For this and other reasons the data for the longer span are regarded as relatively free from extraneous effects. If then one subtracts the values represented by the solid curve from corresponding values on the broken curves the differences should, in a measure, represent the extraneous effects. The differences thus obtained are shown graphically in Fig. 3. One striking feature of these difference-graphs is their consistent nature and the similarity in character. They show a remarkable resemblance to the diurnal change in temperature at that place with, however, some lag in phase.[13] Certain possible sources of these effects as suggested by this observation were examined and it was found that by improving the insulation of the buried portion of the copper conductor, which joins the line with the lead electrode, this feature could be completely eliminated. However, the resistance of the original electrodes was greater than desired, it being at times as much as 2000 ohms per electrode. This necessitated that the insulation between the copper conductor and the adjacent earth be better than with electrodes having lower resistance. Because of this and other considerations, an attempt was made to install new electrodes in such manner and position that they should have much lower resistance. The agreement obtained after these improvements were effected is shown in Fig. 4. While the evidence here shown demonstrates the possibility of obtaining satisfactory measurements of the more quiet aspects of earth-currents, yet it should also indicate the caution which must be exercised if gross errors are to be avoided.

It is, however, not generally feasible to eliminate slower changes of the electrode-potentials. The character of these slower changes as observed at Watheroo are shown in Fig. 5. The ordinates in these graphs are daily means of the measured potential-differences (not gradients); positive values signify that the reference-point is at a higher potential than one to the east or to the north of it. When one observes that the absolute values as well as the changes in these potentials are generally independent of the distance and also of the direction of a point with respect to the reference-point, he necessarily concludes that the more constant part of these measured values, the

[13] O. H. GISH, Carnegie Inst. Wash. Year Book **24**: 214–215. 1925.

daily mean, arises mainly from electrochemical effects of local origin and that this part of the measured quantity should therefore not be regarded as significant. These data give no indication of earth-cur-

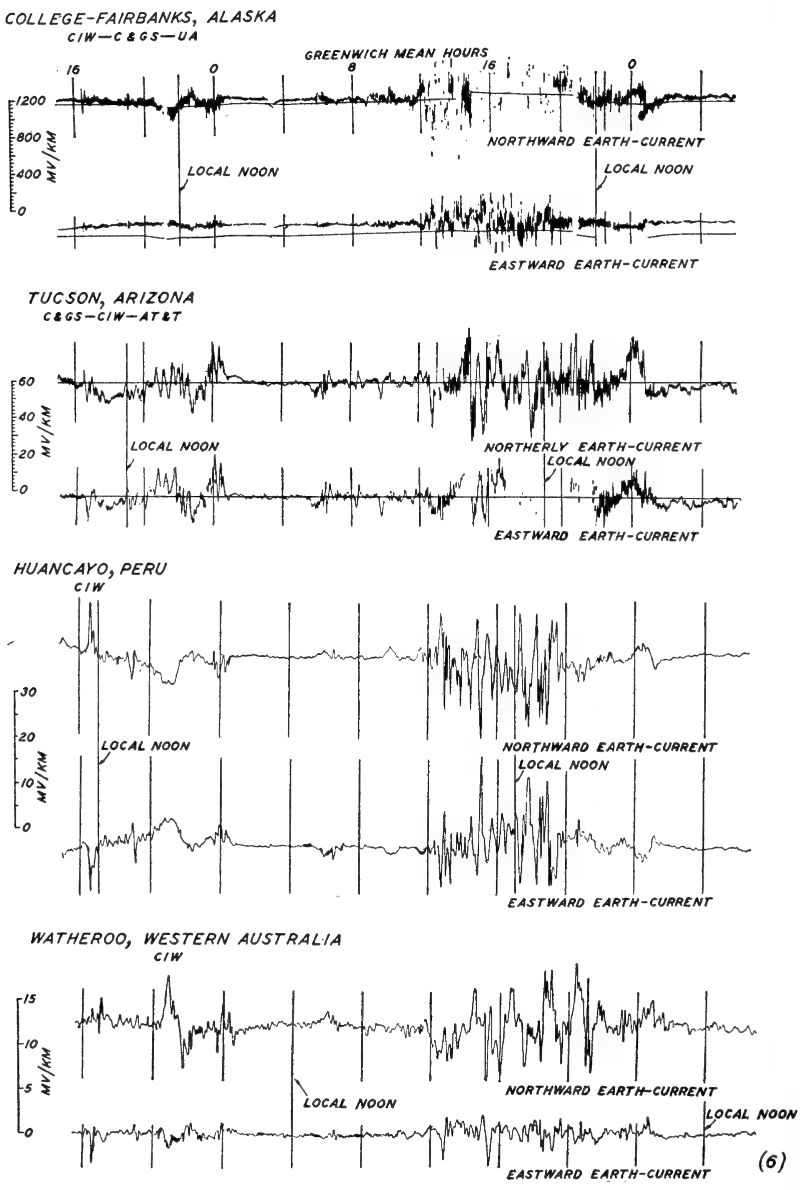


Fig. 6.—Impulsive *messages*. Such as these, which were received April 30 to May 2, 1933, at four places ranging in latitude from 65° north to 30° south, announce events which occur simultaneously over the entire earth.

rents which maintain a constant direction and intensity at a given place. It may also be mentioned that the results obtained at the Huancayo Magnetic Observatory bear this out, but stronger evidence bearing on this point is obtained at the Tucson Observatory, where the lengths of lines are 57 km in the northerly direction and 94 km in the easterly. There the steady part never exceeds 20 per cent of

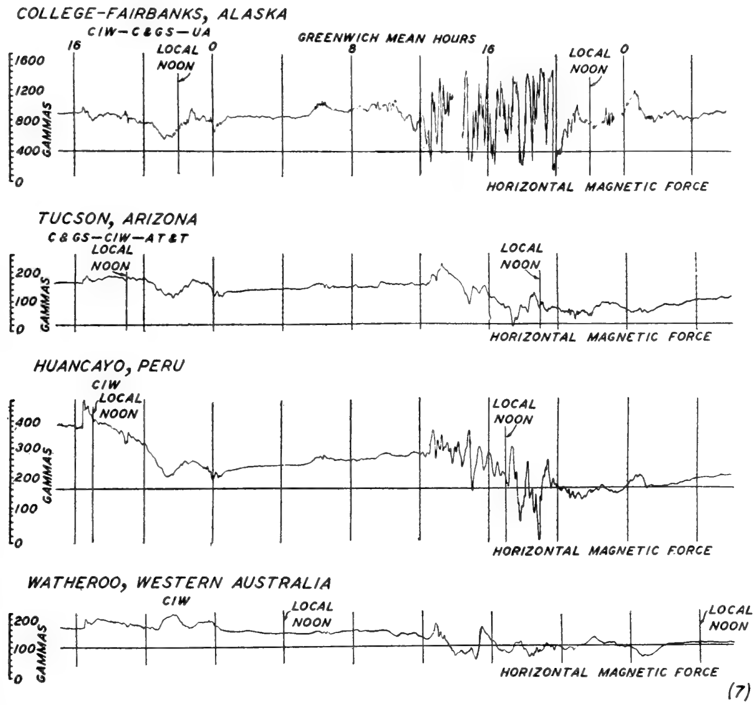
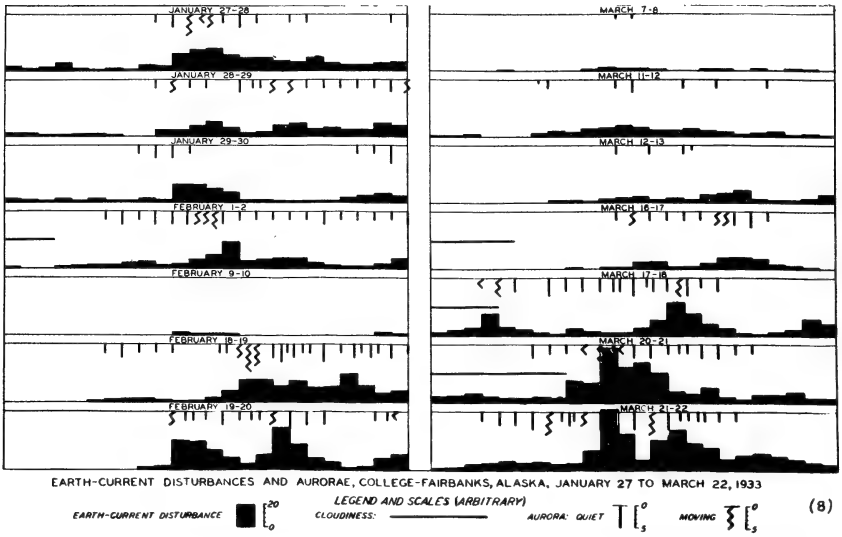
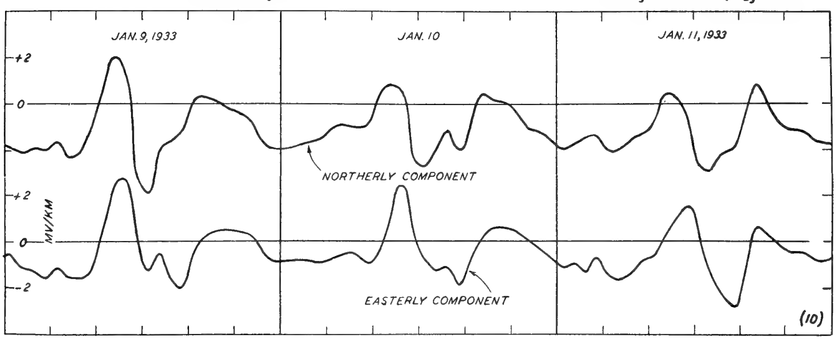


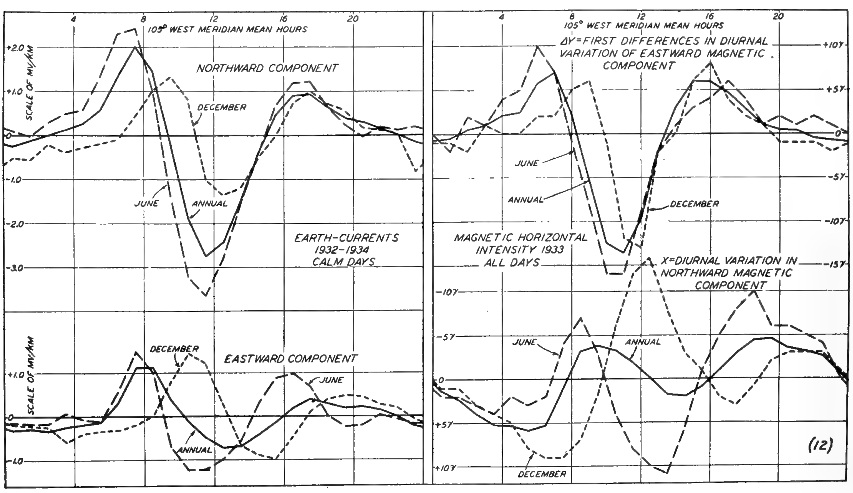
Fig. 7.—Impulsive magnetic *messages.* The magnetic effects shown here correspond to the electrical messages exhibited in Fig. 6. These appear to be magnetic and electric versions of the same narrative.

the amplitude in the daily change and the absolute magnitude of that part of the measured potentials (always less than 0.3 volt) is such that it may be reasonably attributed to local electrochemical effects. This is the justification for omitting the daily means from the numerical data and from further consideration in this discussion.

The definition of earth-currents given in a well-known modern dictionary may be of interest here and will help to stress a point. It is as follows: "Light electric currents apparently traversing the earth's surface, but which in reality only exist in a wire grounded at both ends, due to small potential-differences between the two points at







For explanation of Figs. 8, 10, and 12, see bottom of opposite page.

which the wire is grounded." Although this is not a model definition either as regards content or form of expression, yet the inaccuracy of the content may perhaps be excused on the ground that all so-called earth-current measurements contain an irrelevant element which may be dominant unless recognized for what it is. If then such nondescript grist is innocently put through a crude statistical mill, the meal which comes out may indeed spoil the pudding. One who is about to investigate these phenomena of the earth would do well to start with the attitude of skepticism expressed in this definition, an attitude also recommended for more general application by Francis Bacon when he wrote, "If a man will begin with certainties, he shall end in doubts; but if he is content to begin with doubts, he shall end in certainties."

The information now accumulated enables one to view some of the broader aspects of the system of electric currents which circulate in the earth. One sees that most earth-current storms which are observed in the middle latitudes occur simultaneously everywhere on the earth as illustrated in Fig. 6. Comparing these with the corresponding magnetic records reproduced in Fig. 7, one notices a pronounced similarity in the character of the magnetic and the electric records. When one is disturbed, the other is also disturbed. This, as well as the similarity in the character of the disturbances, is obviously not a mere coincidence.

The correspondence between the occurrence of aurorae and disturbances in earth-currents is represented by Fig. 8. Here the dark blocks represent by their height the degree of disturbance in the earth-currents. The vertical lines above these indicate the occurrence of aurorae, their length being proportional to the brilliance of the aurora. The zigzags indicate moving forms.[7] Further evidence of a relationship between earth-currents, aurora, and possibly solar activity is presented in Fig. 9. This is the result of a statistical study which was designed to determine whether there is a tendency for earth-current storms or polar lights to recur after a period of time, a sort of return engagement.[14] The curves in the right-hand side of

[14] W. J. PETERS and C. C. ENNIS, Terr. Mag., **31**: 57–70. 1926. H. U. Sverdrup, Res. Dep. Terr. Mag., **6**: 510–512. 1927.

Fig. 8.—Electrical *messages* pertaining to polar lights. Displays of polar lights and certain electrical effects observed at College, Alaska, January 27 to March 22, 1933, appear to be related.

Fig. 10.—Tranquil *messages*. This specimen received at Tucson, Arizona, January 9 to 11, 1933, represents a type of message which is repeated day after day, year after year. Such messages vary in intensity with the seasons and may be obscured on occasions when impulsive messages are interjected.

Fig. 12.—Character changes with season. This is especially pronounced at Tucson in both the electric and the magnetic elements, and is equivalent to a shift of latitude.

Fig. 9 indicate the relative frequency at which a storm may follow another storm at intervals of 25 to 33 days. It is noticed that this frequency is greatest at about 27 days after the first occurrence in the case of earth-currents. Although for the aurora the indications are not so positive, yet there appears to be some evidence of a similar recurrence. It should be recalled in this connection that 27 days is the time required for a sunspot to rotate with the sun. A relationship is also found between the variations in earth-currents, the activity of

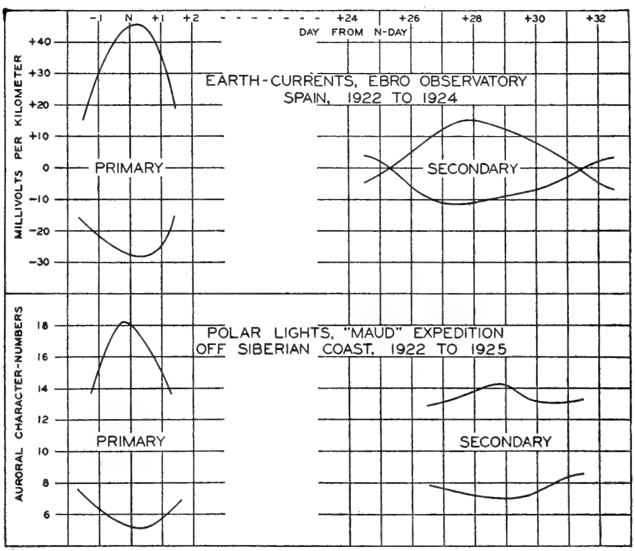


Fig. 9.—Impulsive *messages* repeat. The evidence presented in this chart shows that if an impulsive *message* (an earth-current storm) is received on a certain day, then there is a high probability that another will be received 27 days later. A similar tendency is found for terrestrial magnetism and for polar lights.

the earth's magnetism, and the occurrence of spots on the face of the sun.[15] They all run through a cycle which has a period of roughly eleven years. When sunspots are numerous, magnetic changes are greater and more frequent, and the earth-currents undergo more intense and more frequent fluctuations than at times when sunspots are less plentiful. From such observations one concludes that these earth-current disturbances must arise out of an influence which is capable of acting directly on the whole earth at once and that the activity on the sun in some way influences the electric currents in the earth.

When one examines the more quiet aspects of earth-currents, he finds there regular changes during the day such as appear in Fig. 10. These undergo some modifications from season to season, and they

[15] O. H. Gish, Sci. Mon., **32**: 5–21. 1931.

wax and wane during the years.[15] The average character of the more tranquil changes observed at Tucson, Arizona, are shown by the graphs in Fig. 12. If the amplitudes of these wave-like graphs are chartered for different places and different times of the year, graphs such as those shown in Fig. 11 are obtained. It will be seen from this that the amplitude is a minimum in midwinter whether the stations be north or south of the equator and that in general the values for summer tend to be high, yet there appears to be a tendency for large

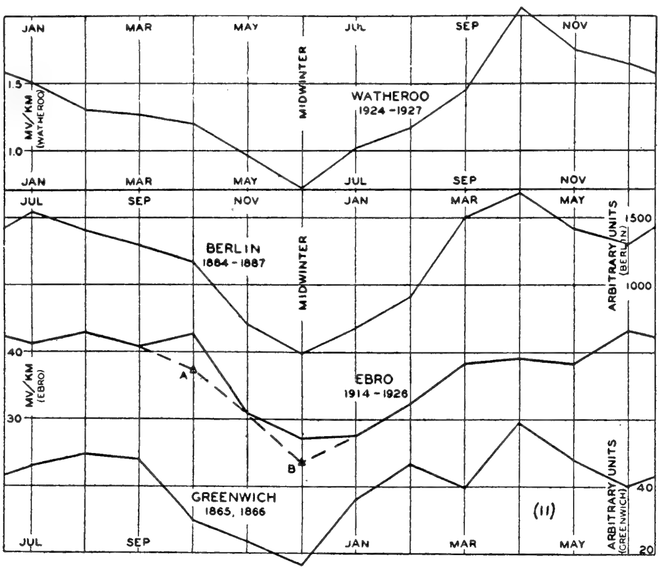


Fig. 11.—Intensity changes with season. The tranquil electric effects are generally more intense in summer than in winter.

values to occur near the time of the equinoxes. There is also evidence that the amplitude of daily change varies with a period of about eleven years and that this corresponds approximately with the variations in sunspot number.[16] The diurnal changes in earth-currents and terrestrial magnetism at Tucson, Arizona, are compared in Fig. 12. Several points of correspondence will be noted in these. The rate of the diurnal change in the westward magnetic component closely resembles the diurnal change in the northward earth-current component. The manner in which both the magnetic and the electric effects change with season at this station is of special interest in that it reveals a further relationship between these two classes of phenomena.

When one attempts to ascertain from the data just what relation-

[16] Carnegie Inst. Wash. Year Book **34**: 234. 1935.

ship exists between earth-currents and terrestrial magnetism, he is confronted with some difficulty. This is especially pronounced in the case of earth-current and magnetic storms. During these storms the changes in the earth-currents are sometimes of the same character as those in the corresponding component of terrestrial magnetism, the two increasing or decreasing in unison (see Figs. 6 and 7). Then again they differ considerably in character although the duration of the disturbed periods corresponds. If the magnetic changes were due to electric currents in the earth, then they should be roughly proportional to the electric changes; thus the graphs which represent the magnetic changes (Fig. 7) should be about the same shape as those for the earth-currents (Fig. 6). However, if the magnetic changes produce the earth-currents, the relationship would be quite different. The earth-currents would then be roughly proportional to the rate of the magnetic changes. Thus, even though the magnetic disturbance be large, if it is changing but little the earth-current at the corresponding time would be small. A comparison of the observed storm-changes in earth-currents and in the earth's magnetism therefore seems to indicate that sometimes one relationship holds, sometimes the other. Viewed superficially this may be taken to indicate that part of the time the earth-currents are the cause of the magnetic changes and part of the time the result of those changes. This apparent duplicity of character, together with the inconstant nature of earth-current storms, are obstacles which stand in the way to a comprehension of them. Since it is not proposed here to venture far into the free and airy realm of speculation, we shall leave this aspect and turn to a further examination of the relation between the more quiet aspects of earth-currents and the corresponding changes in terrestrial magnetism.

When one compares the diurnal variations in these two phenomena, he finds some evidence for the view that the slow periodic changes in earth-currents may be in the main induced by magnetic changes similar to those observed. Thus in Fig. 12 it is seen that the rate of change of the eastward magnetic force at Tucson is of a very similar character to the variations in the northward component of the earth-currents.[6] Such simple comparisons are of course inadequate for more than one reason.

Any electric current must produce some magnetic effect so that it is reasonable to expect that the magnetic changes are not wholly independent of the earth-currents which seem in some way to arise from the magnetic changes. The mathematical relations which take into account such reactions between the inducing magnetic changes and

the induced current were worked out by Chapman and Whitehead.[17] That relation enables one to calculate the components of the earth-currents, or rather the gradient which is proportional to them, from

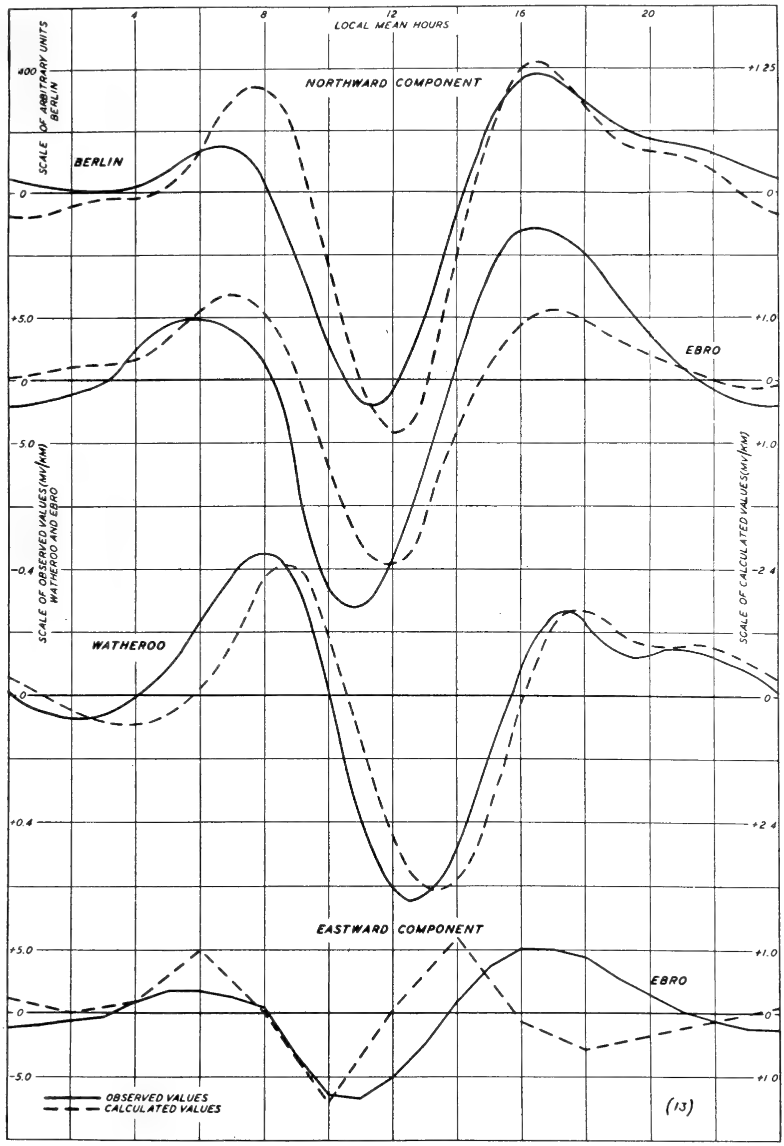


Fig. 13.—A *prediction* after the event. The solid curves represent the average diurnal-variation in the tranquil electric effects. The broken lines are those *predicted* wholly from the tranquil diurnal-changes in terrestrial magnetism.

[17] Cambridge, Trans. Phil. Soc., **22:** 463–482. 1922.

the observed magnetic changes. In Fig. 13 these calculated values of the earth-potential gradient are compared with those which have been observed.[18] There seems to be fair qualitative agreement for the northward component but not for the eastward component. The values calculated for Watheroo are six times those observed. For Ebro the calculated values are one-fifth those observed. No quantitative comparison is possible in the case of Berlin because the observed values are expressed in arbitrary units.[17a] Although the agreement is not as good as one should like, yet there seems to be evidence here to support the view that the regular daily changes in earth-currents are in the main induced by corresponding daily changes in terrestrial magnetism. According to Chapman and Whitehead, the difference between calculated and observed values of the eastward component may perhaps be attributed to an inadequacy of the magnetic data. Referring to the formula used in the calculations they say "the higher harmonics in the magnetic potential are perhaps hardly sufficiently well determined to bear the weight given them in this formula."

Irregularities in the structure of the earth's crust are not considered in making the calculations, yet these present contrasts in electrical conductivity which certainly distort the electric flow. Perhaps the most pronounced large-scale contrast of this nature is that between land and sea, the conductivity of sea-water being several orders of magnitude greater than that of land.[19] Other currents of more or less local extent and of quite different origin may at places be superimposed upon the more general system, thus adding to the complexity (see reference 15). Furthermore, one should not neglect to question the reliability of the earth-current data provided those data were obtained in such a way as to give no criteria by means of which it may be ascertained that extremely local phenomena, especially such as are produced by the method of measurement, have been eliminated. Such modifying influences may account for some of the disparities which have been noted. In any case, the induction theory is the only one now in sight that can claim attention.

One may therefore tentatively entertain the view that the earth-

[17a] Before sending this to press the values of these data were converted to conventional units on the basis of information found in a paper by von Stephan. Berlin. SitzBer. Ak. Wiss. No. 39: 553–561 (1886); see also O. H. Gish, Terr. Mag., **41**: 87–88 (1936). The Berlin data now appear to be only 13 per cent greater than those derived by Chapman and Whitehead.

[18] Calculations for Greenwich and Berlin are given in reference 15, those for Ebro by S. Chapman and T. T. Whitehead in Terr. Mag., **28**: 125–128 (1923), and those for Watheroo by Gish and Rooney have not been published in detail.

[19] H. Ertel gives a helpful theoretical discussion which takes account of contrasts in the electrical conductivity of the earth. Berlin, Veröff. Met. Inst., No. 391 (1932)

currents which are observed are in the main induced by magnetic variations, but that their strength and direction are modified in a manner which varies from place to place and which depends upon the distribution and configuration of oceans and continents as well as upon other structural features of the earth. Modifications produced in the earth-currents by the deep structure of the earth's crust may thus constitute electrical messages which contain information about conditions in that little-known region.

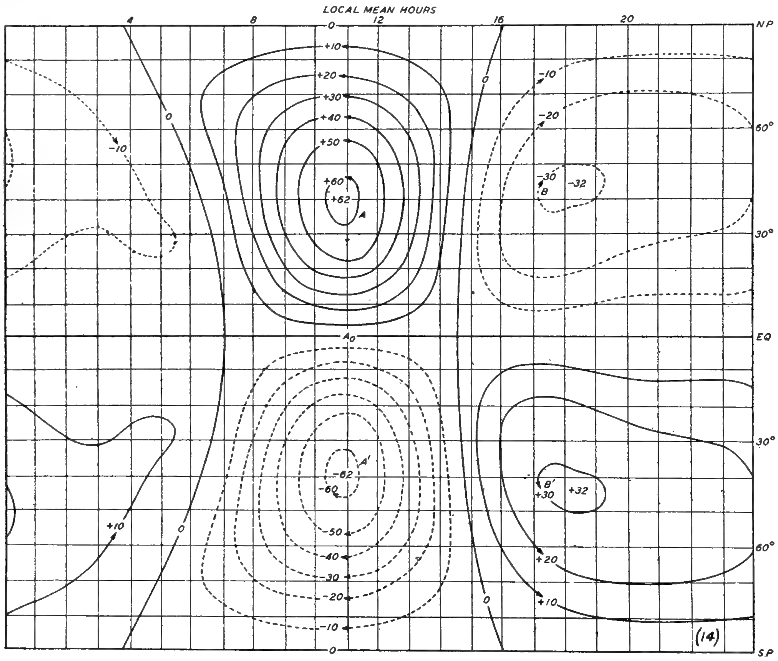
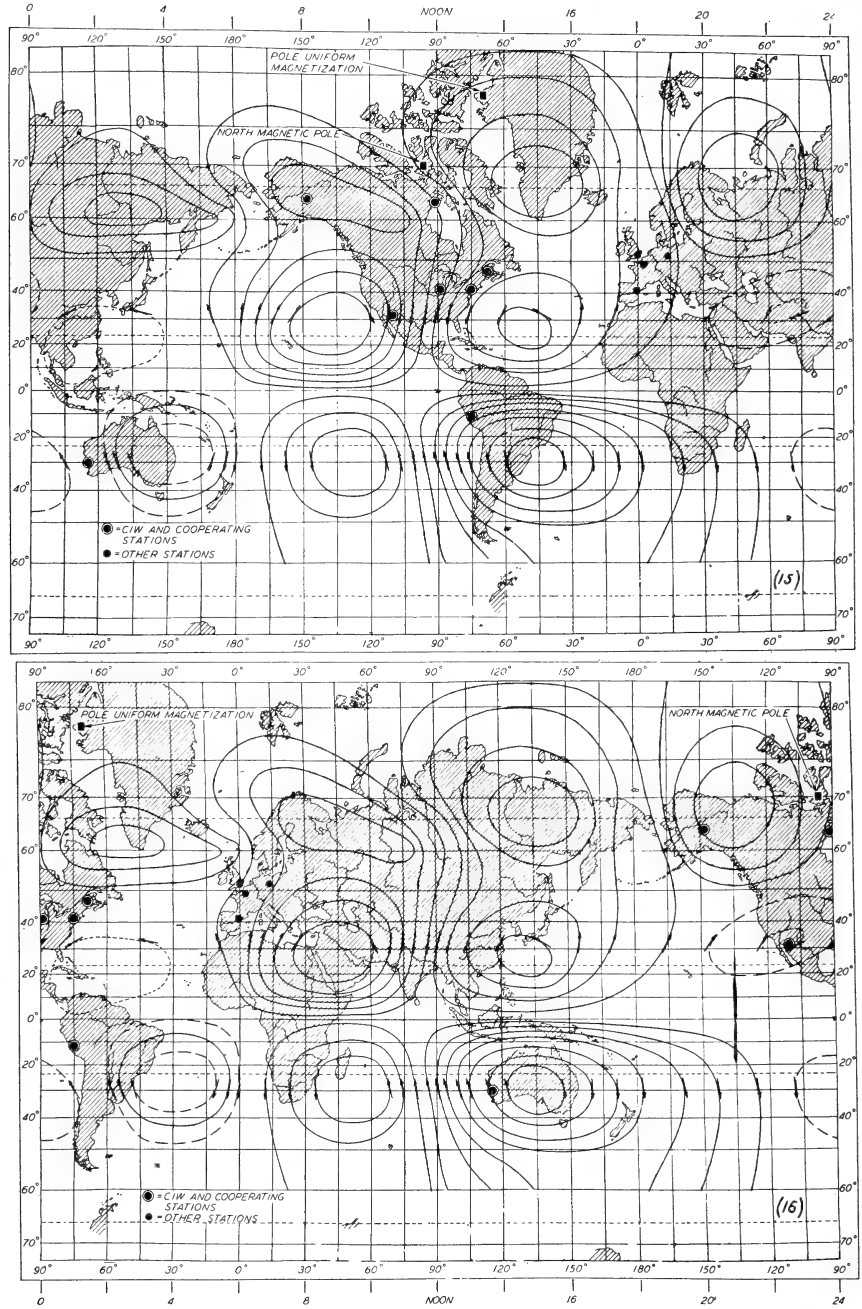


Fig. 14.—Electric currents beyond the stratosphere. Electric currents in the high atmosphere flowing in extensive eddies like those depicted in this world map by Bartels would account for the average tranquil diurnal-changes in terrestrial magnetism. This current-system is fixed relative to the sun and hence the earth rotates within it. The magnetic field of different parts of this system passes over a given place at different times of day, thus bringing a regular daily change in the earth's magnetism.

The magnetic forces which, on the view just outlined, induce the earth-currents have their immediate origin in the high atmosphere in about the same region which reflects radio waves. If a system of electric currents having the character represented by the diagram of Fig. 14 circulates in that region of the atmosphere, it would be capable of producing the daily magnetic changes which are observed at the surface of the earth. To justify the assumption that there exists such a system of currents or any equivalent which may produce the corre-

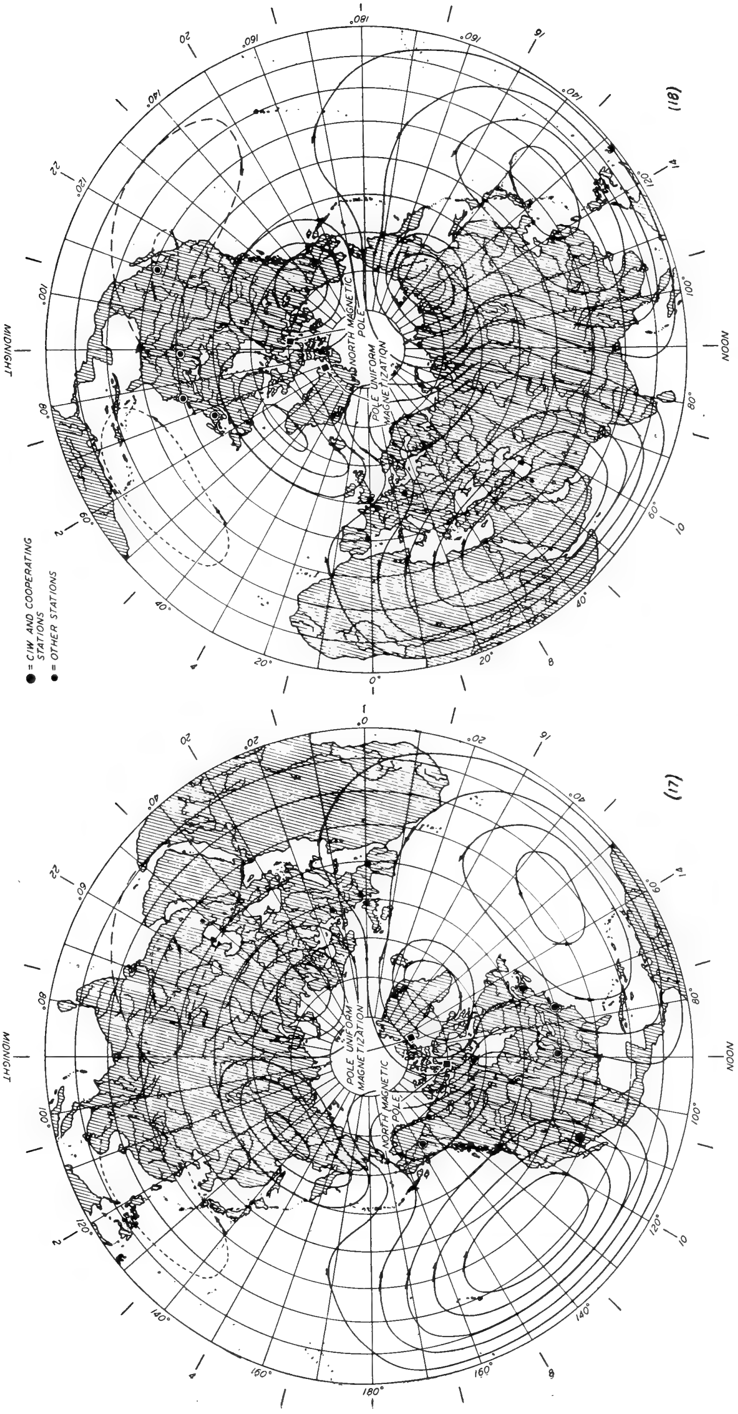


Figs. 15 and 16.—An interpretation: electrical eddies in the earth. The tranquil electric messages as interpreted here refer to electric currents which circulate in extensive eddies in the earth's crust. These, as viewed from the sun at about the time of the equinoxes, are shown here diagrammatically—(a) for daytime over the Western Hemisphere (Fig. 15) and (b) for daytime over the Eastern Hemisphere (Fig. 16).

sponding magnetic effect would carry us beyond the scope of this discussion, since it is here desired to simply point out somewhat of the mechanism by which the electric currents in the earth may be induced. The portion of this system of currents which appears at the center of the diagram is always directly under the sun and therefore the whole system moves relative to the earth, making a rotation once each day. The magnetic field of this electrical circulation as viewed from outside of the earth is one which in its principal features does not change appreciably with time, but, since it is moving relative to an observer on the earth, it appears to him to undergo a regular diurnal variation. This magnetic field, together with the earth which rotates within it, constitute the electric machine which generates the electric currents in the earth. Thus one might expect to find in the earth a general system of electrical circulations which is related to that represented for the higher atmosphere.

It has recently become possible to construct, on the basis of observed data, a world picture of the electric currents which circulate in the earth. This picture shows a number of great electric eddies (see Figs. 15, 16, 17, and 18). Eight of these are located in the middle latitudes, four in the northern hemisphere and four in the southern hemisphere, symmetrically placed on either side of the equator with centers about equally spaced in longitude and lying along a parallel of latitude near the tropics of Cancer and Capricorn (see Figs. 15 and 16). Four more such eddies with centers in the Arctic are also disclosed (see Figs. 17 and 18). Although there are no data to establish the fact, it seems likely that there are also four corresponding eddies in the Antarctic. All of these eddies follow the sun in such a way that there are eight on the sunlit side of the earth and eight on the dark side. The curves which outline the eddies are constructed in such a way that two adjacent curves indicate the boundaries of a tube of flow. Those tubes which are bounded by solid lines all contain the same amount of current except that in the case of the innermost curves the flow is sometimes less than that for a full tube. In order to show some of the weaker eddies it was necessary to subdivide some of the tubes. These are outlined by broken lines. The direction of flow is that of the arrows.

Current-systems corresponding to the charts which are exhibited here would completely account for the average diurnal variations observed in earth-currents at Watheroo, Tucson, and Chesterfield Inlet. Similar charts have been constructed from other sets of data; in fact, all the principal series of earth-current data have been examined in



Figs. 17 and 18.—The polar aspect. The eddies in the Northern Hemisphere—(a) for daytime in the Western Hemisphere (Fig. 17) and (b) for daytime in the Eastern Hemisphere (Fig. 18).

the same manner and without exception they are consistent with a scheme having the general features here depicted. In order that this picture may the better represent the observed facts, the tubes of flow must be regarded as very flexible, easily deformable, so that the shape of the tubes may be readily distorted and even the centers of the eddies displaced in such a way as to conform with the distribution of the electrical properties of the Earth, especially of that portion which constitutes the more immediate environment of a given eddy. It also seems likely that the development and the orientation of the eddies should be in some relation to the magnetic axis of the earth. When the general aspects of pertinent earth-current data are viewed in such a perspective they will, it is believed, be seen to be consistent with the principal features of the interpretation which the charts are designed to convey.

Returning again to an examination of the charts, it will be noticed that the current in the daylight eddies is considerably greater than that in the others; at least this is true for the eddies located in the middle latitudes. The centers of the forenoon eddies of the middle latitudes are approximately on the meridian for which the time of day is 9 a.m., while the afternoon eddies center on the meridian for which the time is about 3 p.m. Considerable flexibility must be allowed for this feature. The circulation in the forenoon eddy of the northern hemisphere and that in the afternoon eddy of the southern hemisphere are clockwise, whereas in the other two daylight eddies the circulation is counter-clockwise. A similar description applies to the nighttime eddies. The circulation in the eddies of the Arctic region is in the same sense as the corresponding eddies of the middle latitudes in the northern hemisphere. As these eddies move relative to the earth the direction and intensity of the earth-current at a given place change, those changes depending upon the position that place may occupy in the eddies and hence depending also upon the latitude of the place. This then is a world view of the gross aspects of the quiet-period earth-currents—the most comprehensive interpretation thus far made of the tranquil electric messages from the earth. It is, however, but a beginning; much deciphering remains yet to be done.

CHEMISTRY.—*Notes on the preparation and composition of wustite phases.*[1] E. E. WOOD and J. B. FERGUSON, University of Toronto.

[1] Received March 25, 1936.

THE DEHYDRATION OF FERROUS HYDROXIDE

Ralston (12) has suggested that ferrous hydroxide might be a suitable material from which to prepare ferrous oxide. Pure white ferrous hydroxide was prepared from aqueous solutions of ferrous sulphate and potassium hydroxide in an atmosphere of nitrogen. It was filtered, washed with water and then dehydrated in vacuo, the whole operation being conducted in a closed apparatus. Great care was taken to exclude extraneous oxygen and the ferrous sulphate solution was prepared by the method of Benson (2). The relative amounts of ferrous and total iron were determined on the same sample without weighing by the electrometric method of Hostetter and Roberts (8).

The dehydration experiments were made at temperatures ranging from 100 to 180°C. and for periods of time varying from 95 minutes to 7.5 hours. We considered the reaction velocity too small at temperatures below 100°C. to warrant work at lower temperatures. The final products always contained ferric iron which was larger the higher the temperature of dehydration. It also increased with time up to a certain point and then remained constant at constant temperature as though the oxidation were directly related to the production of water vapour which was removed by a suitably protected vacuum pump.

Welo and Baudisch (13) seem inclined to attribute the formation of ferric iron, at least in part, to the decomposition of ferrous oxide to form magnetite and iron. We found no trace of gas when a sample was dissolved in acid and doubt if free iron were present in our products and would prefer to regard a wustite as a primary product. Since our most reduced materials only contained 80.4 percent ferrous oxide, this method of preparation is no better than many others and the technique is very much more difficult.

THE DECOMPOSITION OF FERROUS OXALATE

Andrew, Maddocks and Howatt (1) claim to have prepared ferrous oxide, 99.5 percent pure or better, by heating the oxalate in vacuo at the proper temperature. Jette and Foote (9) were unable to duplicate their work. We made a number of experiments and although we varied our procedures in many ways, we were also unable to duplicate the work of the former.

One of the stumbling blocks in such work is the analytical method and Andrew et al. may not have obtained the pure ferrous oxide which their analytical results seem to indicate. But the work of Jette and Foote and of ourselves shows that their method is not a procedure for

the preparation of pure ferrous oxide which can be employed with any reasonable assurance of the production of a pure oxide.

THE REACTION BETWEEN IRON AND MAGNETITE

The early observations of Chaudron (4) indicated that iron and magnetite, formed as decomposition products of wustite, would readily re-combine at higher temperatures. Mulligan (6a) also observed in our laboratory a similar re-combination. But the later work of Chaudron and Forestier (5), as Ralston (12) points out, does not seem to confirm these observations.

In order to be sure that our results might not be determined by a particular wustite sample, we selected a number of materials which differed in preparation and composition for this study. The total and free iron values for these were respectively as follows: A, 75.8 and 0.26; B, 79.2 and 9.1; C, 77.4 and 5.1; and D, 78.7 and 9.5 percentages respectively. These samples were sealed in Pyrex glass tubes in vacuo and heated for five hours at 515°C. (*D*, decomposed) or for five hours at 610°C. (*R* re-combined). The tubes were removed from the furnace and chilled as rapidly as possible. The products were analysed by the electrometric method for total iron using potassium dichromate and by the mercuric chloride method (7) for free iron. Mulligan had previously used the copper sulphate method for free iron. The results are given in Table 1. There are certain irregularities in this table. The

TABLE 1.—THE FREE IRON CONTENT OF HEAT-TREATED WUSTITE.

SAMPLE.	A.	B.	C.	D.
		weight percent		
Initial	0.26	9.1	5.1	9.5
D	12.0	23.65	13.75	20.75
R	0.1	10.2	5.3	7.8
D	8.9	16.4	7.9	11.2
R	0.35	9.1	1.4	6.1

second decomposition and re-combination did not yield the same products as the first. In C and D, the final products contained less free iron than the original materials showing that some of the magnetite and iron formed during the original preparations of these samples had also re-combined. But there is ample evidence that the re-combination of such iron and magnetite is easily obtained and the earlier observations are thus confirmed.

The further question, whether or not iron and magnetite from extraneous sources will readily combine, was also investigated. A finely

ground electrolytic iron and a sample of Kahlbaum's magnetite were selected for this study. The former had been reduced in hydrogen at 800–900°C. and was originally from 100 to 200 mesh material. The latter was an extremely fine powder containing 24.07 percent of iron in the ferrous condition, the theoretical value being 24.12. Various mixtures were heated in vacuo in sealed Pyrex glass or silica glass containers which were removed from the furnace and quenched as rapidly as the containers would permit without breakage. Gas usually formed from the charge in the initial heat treatment and a slight oxidation occurred. We attributed this to air adsorbed on the fine magnetite powder. Because of this gas production and oxidation, the composition of the charge was adjusted by the addition of free iron after this first treatment in cases in which a definite total composition was required. The samples were also ground in an agate mortar in nitrogen between heat treatments in order to uncover residual iron and also prior to analysis and to magnetic separation when this was made. In some experiments with silica tubes, it was found advisable to hold the charge in a container of black sheet iron inside the silica tube to prevent contamination by flakes of silica when the charge was quenched.

Complete combination was not observed in samples high in iron. A sample which initially contained 19.4_2 percent free iron contained 1.63 percent after a heat treatment of 7.75 hours at 691°C. Complete combination was obtained at 1097 ± 10°C. with samples which initially contained 10.9_7 and 8.4_7 percent free iron respectively, and with the former sample (10.97) at 926 ± 3°C. A serious attempt was made to prepare pure ferrous oxide by the complete combination of iron and magnetite in the proper proportions but without success, the products always containing free iron and ferric iron. Since pure ferrous oxide could not be prepared in this manner, attempts were made to find the limits of the wustite field, next to iron, on the iron-oxygen diagram through the use of samples containing initially an excess of iron. The final products were separated by means of a strong electromagnet. A sample which contained initially 80.1 percent total iron was heated for 8.5 hours at 683°C., 5.5 hours at 693°C. and 6 hours at 703°C. The non-magnetic portion contained no detectable free iron, 77.0_3 percent total iron and 70.6_6 percent iron in the ferrous condition. This result agrees fairly well with the value of 76.9 given by Pfeil (11) and also with the value indicated for this temperature on the diagram given by Mathewson, Spire and Milligan (10). Pfeil indicates a vertical boundary line at 76.9 percent and Jette and Foote (9)

found evidence of free iron in samples containing 77.4 percent iron which had been heated respectively at 600, 795, 915 and 1035°C. From the ferrous iron content of samples prepared by us at 1097 and 926°C. we obtained points at 77.0_5 and 76.9 percent total iron which would agree with Pfeil's observations. Since the invariant point, Fe + liquid$\rightleftarrows$wustite at 1380°C. determined by Bowen and Schairer (3), lies at 76.8_3 percent total iron, the boundary line, if vertical in the upper range, must lie nearer iron than this percentage.

Additional experiments at 727°C. indicated that the wustite field extends, at this temperature toward magnetite to at least 76.0 percent total iron and probably as far as 75.2 percent. Since the weight of evidence at present available seems to favour the opinion that pure ferrous oxide is unstable at and below the invariant point at 1380°C. and observers have disagreed upon the exact extent of the wustite field, the question as to whether or not the most stable wustite was obtained in many experiments is a pertinent one. It was our reference (6) to such wustites which has been misinterpreted by Ralston (12) to mean different allotropic forms of ferrous oxide.[2] But there can be no doubt that in many cases unstable wustites must have been formed if the compositions which have been reported can be considered at all reliable. We cannot say that our wustites were the most stable solutions, we can only say that, with this new procedure, we have been able to prepare products which compare favorably with those produced by other methods and that the procedure is relatively simple and convenient.

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[2] Misquotation admitted in private communication.

ZOOLOGY.—*Echinoderms collected by Capt. Robert A. Bartlett in the seas about Baffin Land and Greenland.*[1] AUSTIN H. CLARK, U. S. National Museum.

Capt. Robert A. Bartlett's investigations of the waters about Baffin Land and Greenland carried on during the past few years have resulted in bringing together a noteworthy collection of echinoderms which greatly increases our knowledge of the distribution of these animals in that section of the Arctic.

Especially noteworthy are the records from no less than eleven stations south and west of Baffin Land, previously unknown territory so far as the echinoderms are concerned. Scarcely less interesting are the records from northwestern and eastern Greenland, regions where, because of the formidable difficulties to be overcome, little collecting ever has been done.

The localities at which he collected echinoderms were the following:

LABRADOR: 1. Saglak Harbour.

WEST GREENLAND: 2. Disko Island. 3. Northwest of Upernivik (lat. 74° 21′ N., long. 60° 30′ W.).

BAFFIN LAND AND VICINITY: 4. Three miles south of Salisbury Island, Hudson Strait. 5. Fox Channel. 6. Fox Channel (lat. 66° 30′ N., long. 80° W.). 7. Fox Channel (lat. 66° 43′ N., long. 80° 07′ W.). 8. Southern part of Fox Basin. 9. Fox Basin. 10. Center of Fox Basin. 11. Off the northwestern end of Vansittart Island, Frozen Strait, north of Southampton Island. 12. Sturgis Bourne Strait, eastern end of Hurd Channel, Melville Peninsula. 13. Duckett's Cove, Hurd Channel. 14. South of Cape Martineau, Melville Peninsula. 15. Off Cobourg Island, northwestern Baffin Bay (lat. 75° 40′ N., long. 78° 40′ W.). 16. Off the eastern end of Cobourg Island (lat. 75° 40′ N., long. 78° 50′ W.). 17. Off the eastern end of Cobourg Island (lat. 75° 40′ N., long. 78° 53′ W.). 18. Off the eastern end of Cobourg Island. 19. Off the eastern end of Cobourg Island (lat. 75° 40′ N., long. 78° 55′ W.). 20. Off the eastern end of Cobourg Island (lat. 75° 40′ N., long. 78° 56′ W.). 21. Off the southern end of Cobourg Island (lat. 75° 40′ N., long. 78° 58′ W.).

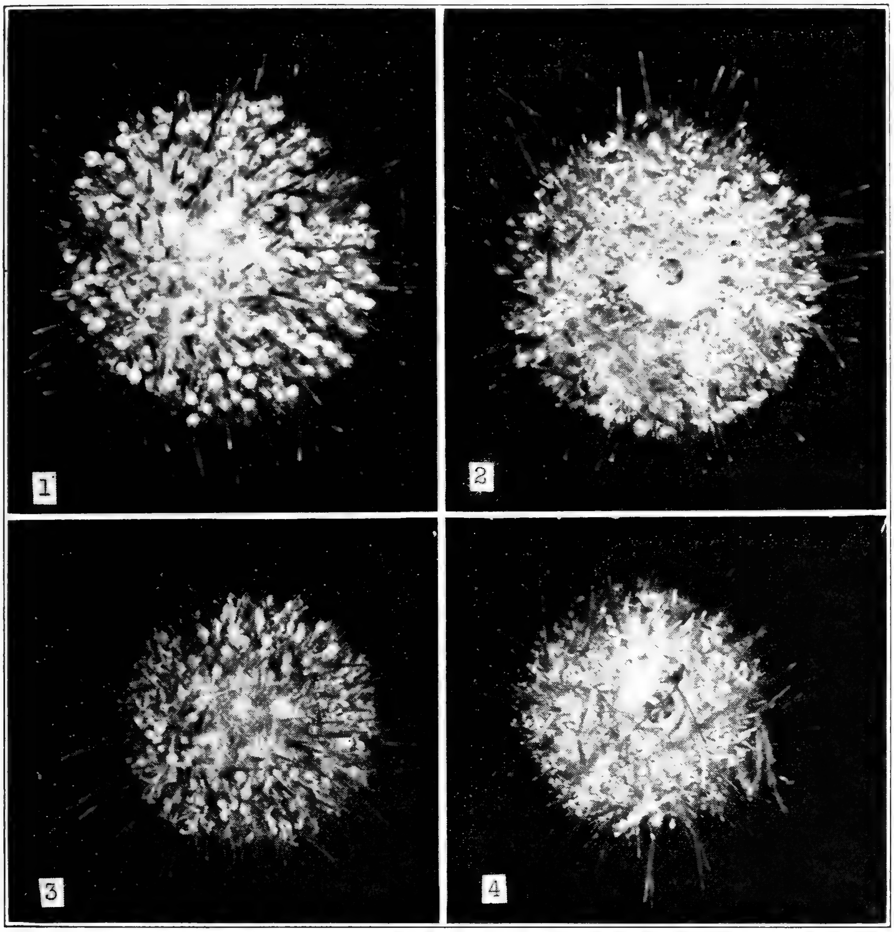
NORTH GREENLAND: 22. Cape York. 23. Kerkotak, Salvo Island, Melville Bay, just east of Cape York. 24. Thule, North Star Bay, north of Cape York. 25. North Star Bay. 26. Parker Snow Bay (lat. 76° 07′ N., long. 68° 20′ W.). 27. Parker Snow Bay. 28. Saunders Island, Westenholm Sound. 29. Off Dalrimple Rock, Westenholm Sound. 30. Five miles south of Cape Chalon, Westenholm Sound. 31. Herbert Island, Whale Sound. 32. Northumberland Island, Murchison Sound. 33. Murchison Sound. 34. Inglefield Gulf. 35. Karnah, Inglefield Gulf. 36. Nerke, near Morris Jessup glacier. 37. Cape Alexander, Smith Sound.

EAST GREENLAND: 38. Angmagsalik. 39. Between Greenland and Jan Mayen (lat. 72° 21′ N., long. 16° 30′ W.). 40. East of Scoresby Sound (lat. 70° 21′ N., long. 16° 30′ W.); 110 fathoms. 41. Off Wollaston Foreland

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received March 10, 1936.

(lat. 74° 04′ N., long. 17° 58′ W.). 42. Off Wollaston Foreland (lat. 74° 20′ N., long. 16° 30′ W.). 43. Clavering Island.

The species collected by Captain Bartlett (exclusive of the holo-



Figs. 1–4.—*Strongylocentrotus dröbachiensis*, two young specimens with the test about 17 mm (Figs. 1, 2) and 13 mm (Figs. 3, 4) in horizontal diameter, aboral (Figs. 1, 3) and oral (Figs. 2, 4) views. Collected by Capt. R. A. Bartlett on the west side of Clavering Island, east Greenland, in 50-15 fathoms, on August 3, 1930.

thurians) were the following. The numbers refer to the localities listed above:

ASTEROIDEA: *Crossaster papposus*, 6, 8, 9, 13, 16, 18. *Henricia sanguinolenta*, 9, 10, 40, 43. *Pteraster militaris*, 9, 10, 43. *Stephanasterias albula*, 9, 10, 14, 18, 24, 28, 31, 32, 34, 35, 37, 38. *Leptasterias polaris*, 4, 43. *Leptasterias groenlandica*, 4, 18, 24, 30, 31, 32, 35, 37, 43.

OPHIUROIDEA: *Ophiacantha bidentata*, 1, 3, 5, 6, 8, 9, 10, 12, 13, 14,

15, 16, 30, 31, 34, 40, 43. *Ophiopus arcticus*, 6, 10, 39, 43. *Amphiura sundevalli*, 43. *Ophiopholis aculeata*, 4, 15, 16, 26. *Ophiocten sericeum*, 13, 15, 17, 19, 22, 25, 28, 32, 36, 38, 43. *Ophiura robusta*, 5, 6, 7, 8, 9, 10, 14, 15, 16, 19, 21, 25, 28, 30, 32, 37, 43. *Ophiura sarsii*, 17, 22, 25, 27, 28, 34, 36, 37. *Stegophiura nodosa*, 13, 22, 29, 43.

ECHINOIDEA: *Strongylocentrotus dröbachiensis*, 1, 2, 4, 10, 11, 16, 20, 21, 22, 23, 25, 28, 29, 30, 32, 37, 40, 41, 42, 43.

CRINOIDEA: *Heliometra glacialis*, 4, 10, 16, 17, 32, 33, 43. *Poliometra prolixa*, 40, 41.

Note.—Worthy of special mention are two small specimens of *Strongylocentrotus dröbachiensis* (Figs. 1–4) from Clavering Island on which, on the aboral surface, the pedicellariae are so very numerous as to be more conspicuous than the spines.

ZOOLOGY.—*A new pocket gopher from New Mexico.*[1] E. RAYMOND HALL, University of California. (Communicated by E. A. GOLDMAN.)

In the spring of 1935 Miss Annie M. Alexander accompanied by Miss Louise Kellogg collected for the Museum of Vertebrate Zoology a series of *Thomomys* from the Rio Grande Valley near Albuquerque, New Mexico. Specimens from this general region had been referred to *Thomomys aureus* Allen, but this was at a time when that name was used in a more inclusive sense than it is at present. It was, therefore, no surprise to find that the gopher from Albuquerque could not be referred to *aureus;* indeed it was knowledge of this probability and curiosity as to the true identity of the pocket gopher there which led Miss Alexander to make special effort to obtain the specimens. Comparisons reveal that the animal from Albuquerque pertains to an unnamed race which is larger, and different in other respects, from *fulvus, tularosae, pervagus, opulentus* and *aureus*, the subspecies of *Thomomys bottae* (see Goldman)[2] whose ranges adjoin that of the new form. For the privilege of making direct comparisons with *opulentus* I am obliged to Major E. A. Goldman and Dr. H. H. T. Jackson of the United States Bureau of Biological Survey. To Dr. H. E. Anthony of the American Museum of Natural History I am similarly obliged for lending the original series used in naming *Thomomys toltecus*.

Thomomys bottae connectens, new subspecies

Type.—Male, adult, skull and skin; no. 66627, Mus. Vert. Zool.; Clawson Dairy, 5 miles north of Albuquerque, 4,943 feet elevation, Bernalillo County, New Mexico; May 6, 1935; collected by Annie M. Alexander, original no. 2981.

[1] Received January 3, 1936.
[2] Proc. Biol. Soc. Washington **48:** 135, 150. 1935.

Range.—Valley of the Rio Grande in central New Mexico, probably from northern Socorro County northward to Bernalillo.

Diagnosis.—Size: Large (see measurements). Color: In fresh summer pelage cinnamon buff (color terms after Ridgway)[3]; whitish below with plumbeous areas and with cinnamon buff extending onto pectoral region, and sometimes to other sections of the underparts; insides of cheek pouches and usually nose, blackish; postauricular patches small. Winter pelage with a reduced amount of cinnamon buff on the upper parts producing a "gray" coat. Skull: Large; rostrum broad and its length amounting to more than 67 percent of zygomatic breadth; nasals posteriorly truncate; hamulus of lacrimal large; interpterygoid space V-shaped and provided with median spine.

TABLE 1.—MEASUREMENTS IN MILLIMETERS OF ADULT TOPOTYPES AND TYPES OF T. B. CONNECTENS AND T. B. TOLTECUS

Catalogue number	*Connectens*								*Toltecus*		
	66638	66642	66635	66636	66634	66627	66628	Aver-age	5440/4305	5386/4304	Aver-age
Sex	♀	♀	♂	♂	♂	♂	♂	♂	♂	♂	♂
Total length	240	232	257	270	267	256	256	261	—	—	—
Length of tail	72	66	76	73	74	68	70	72	—	—	—
Length of hind foot	32	31	36	35	35	35	35	35	29[b]	27[b]	28[b]
Basilar length	37.2	35.5[a]	44.5[a]	42.5	41.1	42.7	40.0	42.2	37.5	38.2[a]	37.9
Length of nasals	14.7	13.5	17.8	17.4	16.7	17.0	16.8	17.1	14.2	14.8	14.5
Zygomatic breadth	25.3	25.4	31.0[a]	31.1	30.3	29.5	—	30.5	28.2	28.7	28.5
Mastoid breadth	20.9	20.9	25.5	24.3	24.5	23.7	22.8	24.2	21.6	23.8[a]	22.7
Breadth of rostrum	8.8	7.2	11.1	10.2	11.0	10.3	10.0	10.5	8.4	9.1	8.8
Interorbital constriction	6.9	7.2	7.2	7.2	7.4	7.3	7.7	7.4	6.7	6.5	6.6
Maxillary tooth-row	9.1	8.3	9.8	9.4	9.1	9.4	9.3	9.4	8.5	8.0	8.3
Extension of premaxillae posteriorly to nasals	2.1	2.9	2.2	2.2	3.3	3.2	2.6	2.7	3.3	3.4	3.4
Depth of skull	16.3	15.5	19.0	17.9	18.3	18.0	17.3	18.1	15.9	16.6	16.3
Length of rostrum[c]	17.7	16.9	21.8	21.7	24.4	21.2	19.7	21.8	18.0	17.5	17.8

[a] Estimated.
[b] Measured from the dried skin.
[c] Measured between the anterior border of the nasals and the maxilla at the lateral end of the hamulus of the lacrimal.

Comparisons.—Compared with *Thomomys bottae aureus*, *connectens* is larger in external measurements, darker colored above, and below has the pectoral region strongly marked with cinnamon buff rather than white, and it is larger in every cranial measurement taken. The interpterygoid space is V-shaped rather than U-shaped; the exoccipital extends farther laterally, revealing an inverted V-shaped rather than inverted U-shaped, face of the mastoid portion of the auditory bulla; the rostrum, relative to the basilar length, is longer and wider; and the skull is more than a fourth heavier as shown by the crania of adult males without lower jaws which average 4.66 grams as against 3.33 grams.

Compared with specimens of *Thomomys bottae opulentus* from Las Cruces (1), Garfield (5), Las Palomas (1) and San Marcial (6), *T. b. connectens* is slightly less reddish above and especially below, is larger in external and cranial measurements—in many parts of the skull constantly so. The skull of *connectens* is by actual weight much heavier: males average 4.6 grams as against 2.5 and females average 2.6 grams as opposed to 1.9. In *connectens* the premaxillae extend farther behind the nasals, the external meatus is prolonged into a distinct tube, the temporal ridges approach one another more closely, the hamulus of each lacrimal bone is as large again, the exoccipital

[3] Color standards and color nomenclature. Washington, D. C. 1912.

extends farther laterally revealing less of the mastoid portion of the auditory bulla, and the skull is generally more angular with better developed processes and ridges marking areas of muscle attachment.

Compared with 5 topotypes and the type of *Thomomys bottae toltecus*, *T. b. connectens* is slightly lighter colored, has much longer hind feet (on dry skins, adult males measure 33 mm. as against 29 mm.) and is constantly larger in every part measured, except for the mastoid breadth and extension of the premaxillae posteriorly to the nasals. In the two parts of the skull indicated there is a slight overlap in measurements. Relative to the basilar length each of the five adult males of *connectens* has longer nasals and rostrum, broader rostrum and a lesser width across the zygomatic arches than has either of the two adult males of *toltecus*. In *connectens* the length of the rostrum amounts to more, rather than less, than 67 percent of the zygomatic breadth. Also, in *connectens* the hamulus of each lacrimal bone is as large again and the inferior margin of the anterior opening of the infraorbital canal is continued anteriorly as a distinct ridge rather than curved upward to form part of an ellipse. Measurements, for the most part not previously available, for *toltecus* are offered above as facilitating comparison with related races.

Remarks.—Among named subspecies of *T. b. bottae* whose ranges approach nearest to that of *connectens*, probably greatest similarity is shown to *T. b. aureus*. The range of *connectens*, as known to me, however, is separated from that of *aureus* by a large area from which no specimens have been examined though the species *T. bottae* doubtless occurs in suitable environments there. The northwestern limits of range of *connectens*, then, remain to be determined. Specimens from Socorro are variously intermediate in color and to a certain extent in external measurements between *connectens* and *opulentus* but cranially they agree well with the latter.

Specimens examined.—Total number, 19 as follows: Type locality, 14; 4.5 miles south Albuquerque, 4,943 feet elevation, Bernalillo County, New Mexico, 4.

ZOOLOGY.—*A note on* Dictyocaulus *from domestic and wild ruminants.*[1] G. DIKMANS, Zoological Division, Bureau of Animal Industry. (Communicated by MAURICE C. HALL.)

Chapin (1925) described as *Dictyocaulus hadweni* n. sp. a nematode collected from the lungs of the American bison, *Bison bison*, at Wainright, Alberta, Canada, by Dr. Seymour Hadwen. Following the description, Chapin devoted a short paragraph to a comparison of *D. hadweni* with *D. filaria*, and differentiated *D. hadweni* from *D. filaria* by the more abrupt termination of the dorsal rays, the complete fusion of the medio-lateral and postero-lateral rays, and the longer spicules. Apparently the use of the name *Dictyocaulus filaria* should be considered as a *lapsus calami* for *Dictyocaulus viviparus*, or else Chapin really intended to compare *D. hadweni* with *D. filaria*. *D.*

[1] Received March 17, 1936.

hadweni resembles *D. viviparus* in the characters mentioned by the author and there would, therefore, have been some reason for attempting to differentiate between them, but *D. filaria* differs so markedly from *D. hadweni* in the conformation and size of the spicules alone that comparisons on any points other than spicules would be the only ones in order. Chapin stated that *D. hadweni* differs from *D. filaria* "in the longer spicules," and from this statement the reader would infer that the spicules of *D. hadweni* are longer than those of *D. filaria* whereas, as a matter of fact, the spicules of *D. hadweni* are shorter than those of *D. filaria*. Since this fact could not have escaped

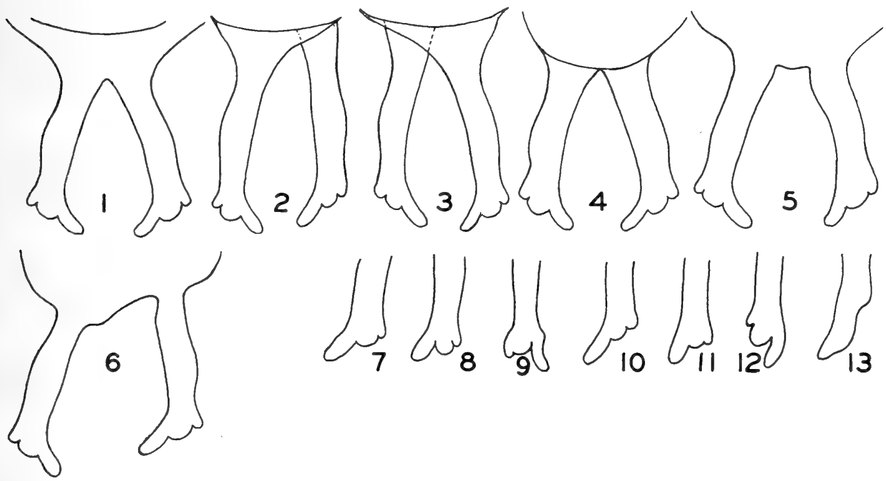


FIG. 1.—Dorsal rays of bursa of *Dictyocaulus viviparus* showing (1–6), variations in position and, (7–13), variations in termination.

Chapin's attention if he had made a comparative study of these two nematodes, it might be inferred that the use of the name *D. filaria* was actually a *lapsus calami*. However, this inference also meets with difficulties because had the author intended to compare *D. hadweni* with *D. viviparus* and had he made a comparative study of these two forms he would have noted their similarity in the very points on which he attempted to differentiate them, viz., the fusion of the mediolateral and postero-lateral rays, the position and termination of the dorsal rays, and the conformation of the spicules, the spicules of *D. hadweni* differing from the spicules of *D. viviparus* in size only.

For some time the writer has been making all identifications of lungworms from domestic and wild ruminants as these have been referred to the Zoological Division for determination, and during that time considerable difficulty has been experienced in differentiating *D.*

hadweni from *D. viviparus* on any valid morphological grounds. Dr. W. E. Swales of the Institute of Parasitology, McDonald College, Quebec, Canada, under a coöperative agreement for exchange of specimens in various parasite groups, has referred specimens of *Dictyocaulus* collected from cattle and various wild ruminants in Canada to the Zoological Division of the Bureau of Animal Industry for study.

Since the females of species of *Dictyocaulus* are, for all practical purposes, indistinguishable, the writer has based his study of the members of the genus occurring in ruminants in North America on a comparison of male specimens, with special reference to the character and relative position of the rays of the bursa, the termination of the dorsal rays, and the size and morphology of the spicules. These studies give the following results: The ventro-ventral ray is always shorter than the latero-ventral ray, but there is no fixed ratio between the lengths of these 2 rays, and their relative lengths cannot be considered as a diagnostic character; the externo-lateral ray is always single and in position is widely separated from both the latero-ventral and the fused medio-lateral and postero-lateral rays; the externo-dorsal ray is single and somewhat shorter than the rays on either side of it; the dorsal rays are doubled, their positions and terminations vary considerably (fig. 1), and no specific value can be attached to either their position or their termination. The conformation of the spicules of *Dictyocaulus* from cattle, *D. viviparus*, is similar to that of the spicules of available specimens of *Dictyocaulus* from wild ruminants. In general the spicules of *Dictyocaulus* from wild ruminants are somewhat longer than the spicules of *D. viviparus* from cattle, but there is considerable overlapping (table 1).

So far as the females of *D. hadweni* and *D. viviparus* are concerned there are no definite morphological characters on which they can be separated from each other. It appears, therefore, that *D. hadweni* cannot be separated from *D. viviparus* on any valid, morphological grounds and, since *D. viviparus* is the older name, *D. hadweni* must fall into synonymy so far as its morphology is concerned. Only carefully controlled feeding experiments could establish whether we are dealing with biological varieties capable of infecting only cattle or only deer or whether these nematodes are biologically as well as morphologically identical.

Hsü (1935) described as *Dictyocaulus khawi* a nematode stated to have been collected from the lungs of swine in Tonkin, French Indo-China. The only point in which this nematode is said to differ from

D. viviparus is that one of the 3 digitations of the dorsal ray has an externo-lateral position. In view of the fact that the terminations of the dorsal rays may be extremely variable in position and appearance (fig. 1) this minor difference does not appear to be sufficient for the creation of a new species. On morphological grounds, therefore, *Dictyocaulus khawi* would also be considered as a synonym of *Dictyocaulus viviparus*, but in view of the fact that over most of the world *Dictyocaulus* is not found in pigs in spite of evident opportunities for

TABLE 1.—LENGTH OF SPICULES OF DICTYOCAULUS VIVIPARUS COLLECTED FROM DIFFERENT HOSTS

Hosts	No. of male specimens examined	Minimum length of spicules in microns	Maximum length of spicules in microns
Cattle *Bos taurus*	29	220	255
American bison *Bison bison*	14	220	295
Moose *Alces americana*	1	255	255
Elk *Cervus canadensis*	10	255	325
Reindeer *Rangifer tarandus*	12	220	315
Black-tailed deer *Odocoileus columbianus*	3	235	300
White-tailed deer *Odocoileus virginianus*	4	176	220
Mule deer *Odocoileus hemionus*	3	220	220
Red deer, probably *Cervus canadensis*	4	255	295

infection from cattle, there is the possibility that under special conditions existing in French Indo-China a strain of *D. viviparus* has become adapted to swine, as *Necator americanus* of man appears to have become adapted to swine in the West Indies, with the development of a new biological species which may show, as does *N. suillus*, certain fixed morphological characters, however slight, differentiating it from the parent species. Since Hsü did not collect the specimens which he describes there is, of course, also the possibility of error in labelling to be considered.

Skrjabin (1931) described as *Dictyocaulus eckerti* a worm found in the lungs of reindeer in the U.S.S.R. He stated that this worm differs from *D. viviparus* as follows: *a*, In the presence of cervical papillae

(these are not mentioned in the part of the paper describing the nematode); *b*, in the presence of a mouth capsule; *c*, in the length of the spicules; *d*, in the structure of the terminal portion of the dorsal ray. The length of the spicules is given as 290 to 310μ and the figures accompanying the description show that they are morphologically similar to the spicules found in *D. viviparus*. The figure of the bursa of *D. eckerti* shows that the termination of the dorsal rays is similar to that of *D. viviparus*. With reference to the presence of a mouth capsule, the presence of a small, shallow, mouth capsule is a character of the genus and an examination of a number of specimens of *D. viviparus* collected from cattle at Bethesda, Md., shows that this character is present in *D. viviparus* from cattle as well as in *D. eckerti* from reindeer in the U.S.S.R. With reference to the presence of cervical papillae in *D. eckerti*, there appears to be no other record of the presence of these structures in members of the genus *Dictyocaulus*, and a careful examination of a number of specimens from both cattle and reindeer failed to reveal their presence. No information is furnished as to the appearance and location of the cervical papillae in *D. eckerti*. From Skrjabin's description and from the figures accompanying it, it appears that the lungworm collected from reindeer in the U.S.S.R. does not differ materially from *Dictyocaulus* collected from the lungs of reindeer in Alaska, aside from the rather surprising occurrence of cervical papillae in the former, and aside from this one item *D. eckerti* appears to be identical with *D. viviparus*.

DICTYOCAULUS VIVIPARUS (Bloch, 1782) Railliet and Henry, 1907

Synonyms.—*Gordius viviparus* Bloch, 1782; *Ascaris vituli* Bruguière, 1791; *Strongylus vitulorum* Rudolphi, 1809; *Strongylus micrurus* Mehlis, 1831; *Dictyocaulus hadweni* Chapin, 1925; (?) *Dictyocaulus eckerti* Skrjabin, 1931; (?) *Dictyocaulus khawi* Hsü, 1935.

Hosts.—Cattle, *Bos taurus;* American bison *Bison bison;* Moose, *Alces americana;* Elk, *Cervus canadensis;* Reindeer, *Rangifer tarandus;* Black-tailed deer, *Odocoileus columbianus;* white-tailed deer, *Odocoileus virginianus;* Mule deer, *Odocoileus hemionus;* Red deer, probably *Cervus canadensis;* (?) Swine, *Sus scrofa domestica.*

DICTYOCAULUS FILARIA (Rudolphi, 1809) Railliet and Henry, 1907

Dictyocaulus filaria is the common lungworm of sheep in North America, and has been collected also from the black-tailed deer, *Odocoileus columbianus*, and from the white-tailed deer, *Odocoileus virginianus*. In 24 male specimens from both deer and sheep, the length of the spicules varied from 330 to 580μ, spicules 330μ long and 580μ long each being found once and the lengths of all other spicules varying from 365 to 515μ. The ventro-ventral ray was found to be shorter than the latero-ventral ray in all the specimens

examined. The dorsal rays terminate in 3 processes but the position of these processes varies to such an extent that no diagnostic significance can be attached to it.

Bhalerao (1932) described as *Dictyocaulus unequalis* a nematode collected from the large bronchi of a Tibetan sheep. He stated that this nematode differs from *Dictyocaulus filaria* in having shorter spicules, only one male 28 mm long, with spicules 280 to 290μ long, being available for examination, and also in that the ventro-ventral ray of the bursa was shorter than the latero-ventral ray, and he gave the specific name *unequalis* because of this inequality of the ventral rays. Since the ventro-ventral ray in *Dictyocaulus* is usually shorter than the latero-ventral ray, this supposed difference between *D. filaria* and *D. unequalis* disappears and, in the absence of any noticeable morphological difference, the difference of 40 to 50 microns in length in spicules based on the examination of a single specimen does not appear to be sufficient reason for the making of a new species when an otherwise identical species has a range of 250 microns. *Dictyocaulus unequalis* is, therefore, considered as probably a synonym of *D. filaria*.

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BOTANY.—Eriogonum intrafractum, *a new species and new subgenus from Death Valley, California.*[1]

FREDERICK V. COVILLE AND C. V. MORTON, U. S. National Museum.

In the spring of 1932 the senior author and Mr. M. French Gilman, while studying the flora of Death Valley, California, under the auspices of the National Geographic Society, found a peculiar-looking perennial species of *Eriogonum*, which because of its immaturity remained unnamed. The plants were found in Titus Canyon, Grapevine Mountains, six miles below Leadfield, at an altitude of about 2,000 feet, growing in the crevices of a blue limestone ledge sloping to the north. The dead stems of the preceding year were about three feet high. Mr. Gilman revisited the locality and obtained additional specimens in 1934. These also were immature, and it was not until October, 1935, that Mr. Gilman was able to obtain good material,

[1] Published by permission of the Secretary of the Smithsonian Institution. Received February 26, 1936.

this indicating at once a new species which can not be referred to any of the recognized subgenera of *Eriogonum.* The new subgenus described below must therefore be added to the already rather long list of plants endemic to this peculiar region.

Eriogonum subgenus **Clastomyelon**[2] Coville & Morton, subg. nov.

Herbae perennes, caulibus erectis, altis, infra inflorescentiam non ramosis, fistulosis, demum interne transverse articulatis; folia radicalia, longe-petiolata, pilosa; involucra sessilia, in verticillis disposita, late campanulata, non angulata, mox fissa et explanata, bracteolis nonnullis suffulta; bracteolae involucrorum saepe virides, crassae; pedicelli florum pubescentes; fructus basi bulboso-expansus, perspicue 3-cristatus, medio abrupte contractus.

TYPE SPECIES: *Eriogonum intrafractum* Coville & Morton.

Three subgenera of *Eriogonum* have commonly been recognized, namely, *Ganysma, Oregonium,* and *Eueriogonum,* from all of which the new subgenus *Clastomyelon* differs in the following characters:

1. *Articulate stems.* The main stem (which is erect, leafless, and unbranched) is divided into many transverse articulations. These, averaging about 5 mm in length, do not become obvious until the plant is past maturity, at which time they are easily visible as undulations beneath the outer stem covering. The latter at length weathers into shreds, and the moniliform articulations fall off one by one. Concerning this feature M. Gilman wrote: "When examining the Eriogonums notice the very peculiar structure of the larger parts of the stalks. Under the bark the stems are made up of little rings from one-fourth to three-fourths inch long. When old the bark falls away, leaving the stems made up of a series of white sections or joints looking like tiny napkin rings. The rings easily unjoint when weathered enough, and on the ground around old plants the fallen stems indicate the vintages of the different years' growth of stalks." These facts are obvious on several of the herbarium specimens cited.

2. *Whorled involucres.* Except on the ultimate branches of the stem the involucres are sessile and borne in whorls. They are usually three in number, each corresponding to an outer bract; but inasmuch as each is voluminously filled with flowers and bractlets, the general appearance is that of a series of heads with the stems going through the middle. Such an inflorescence is unknown in any of the other subgenera, in which the involucres are borne singly in cymes, or in true terminal heads.

3. *Early ruptured involucres.* The involucre itself is broadly campanulate, unangled (a further distinction from the subgenus *Oregonium,* to which *Clastomyelon* is most nearly allied), and deeply 5-partite. The expanding flowers soon rupture the involucre, however, so that at maturity it is flat and platelike, or in old material often appears as though composed of distinct lobes, thus masking the identity of the plant with *Eriogonum.*

4. *Hairy pedicels.* The pedicels of the individual flowers within the involu-

[2] From κλαστός, broken, and μυελόν, pith.

cre are definitely pilose. Although no general statement has been made in the literature concerning the pedicels in the various subgenera of *Eriogonum*, we find by study of the almost complete representation of recognized species in the National Herbarium, that they seem to be uniformly glabrous, except for a very few species, in which they bear minute glands. The hairs in *Clastomyelon* are often somewhat deciduous after maturity.

5. *Flask-shaped, crested fruits.* The fruit of *Clastomyelon* is very peculiar in form, being conspicuously bulbous-dilated at base and trilobate, each lobe bearing a conspicuous rounded crest, filled with pithlike tissue. At the middle the fruit is abruptly contracted, the upper portion being slender and sharply triangular. Although it is not possible to say at present that such fruits are not found in species of other subgenera, it seems likely that that is true. At least, in none of the species that we have examined has there been any approach to this condition.

The above mentioned characters by which *E. intrafractum* differs from all previously known species seem to us amply sufficient ground for the creation of a new subgenus, to take a place coördinate with the three other recognized subgenera. Additional characters of merely specific importance, which will separate the present species from others of the genus, are the tall leafless stems, usually more than one meter high and unbranched up to the inflorescence, the relatively large, long-petiolate basal leaves, uniformly short-pilose (but not at all tomentose) on both surfaces, the numerous accessory bractlets present in the inflorescence (including an involucre of three basally united bractlets present at the base of each involucre), the minutely pubescent perianth (ochroleucous when young, yellow and rose in age), deeply constricted at the middle and with flaring limb, and the unequal perianth segments. In most species of *Eriogonum* with unequal segments, the inner are shorter and narrower than the outer, but in *E. intrafractum* the reverse is true.

Eriogonum intrafractum Coville & Morton, sp. nov.

Herba perennis, caulibus erectis, altis, solitariis, teretibus, non ramosis, glaucis, fistulosis, demum interne perspicue articulatis; folia basalia, longepetiolata, late oblonga obovatave, apice rotundata, basi cuneata, utrinque breviter pilosa; involucra in verticillis circum ramos inflorescentiae disposita, sessilia, aperte campanulata, 5-lobata, pubescentia, non angulata, mox fissa; florum pedicelli pilosi; perianthium ochroleucum, demum basi roseum apice luteum, basi rotundatum, medio constrictum, segmentis externe pubescentibus, exterioribus quam interioribus brevioribus et angustioribus; fructus basi bulboso-inflatus, trilobatus, lobis cristatis, medio abrupte contractus, apice angustus, triangularis.

Perennial herb with a thick woody taproot; stems erect, 0.9–1.2 m long, usually solitary, terete, up to 11 mm in diameter, unbranched except in the inflorescence, there two or three times subdichotomously (or rarely trichotomously) branched, glabrous, glaucous-green, fistulous, internally transversely articulate into short segments 3–9 or even 16 mm. long, the outer layer at length exfoliating, thus allowing the stramineous, moniliform articulations to fall off separately; leaves all basal, long-petiolate, the

petioles pale yellow, densely short-pilose, exceeding the blade in length, the latter broadly oblong or obovate, up to 7 cm long and 3.5 cm wide, rounded at the apex, cuneate at the base, yellowish or grayish green, membraneous, entire, plane, densely and uniformly short-pilose on both surfaces, the midvein and 3 or 4 prominent secondary veins pale yellow, prominently elevated beneath; secondary rosettes of leaves often borne at the base of the stem; bracts at the primary furcation of the stem whorled, about 5, ovate, acute, densely short-pubescent, deciduous; inflorescence subspicate in appearance, consisting of densely flowered involucres borne in whorls up the branches, or these solitary on the ultimate branches; bracts subtending each whorl of involucres three, free, oblong, about 3 mm long and 1.4 mm wide, sharply acute, pilosulous on both surfaces, fleshy, green; internal accessory bractlets of two kinds: (1) 3 bractlets at the base of each involucre, similar in shape and texture to the outer bracts but smaller and united at base and forming a single tripartite bract, (2) supernumerary bractlets (usually narrowly oblong) irregularly disposed between the outer bracts and the involucres; involucres sessile, openly campanulate, 5-lobed, about 3 mm long, pubescent on both surfaces, fleshy, not angled, the lobes ovate, erect, about 1.5 mm long, the tube ruptured in one or several places at maturity by the expanding flowers, the entire involucre then becoming flat and plate-like; pedicels of the flowers pilosulous, interspersed with numerous linear-oblanceolate pubescent bractlets, these sometimes fleshy and green; perianth ochroleucous, in age becoming rose at the base and yellow toward the apex, 3 mm long, rounded at the base, definitely constricted at the middle, there about 1.7 mm wide, flaring and about 2.2 mm wide at the apex, the segments minutely pubescent externally, the outer broadly oblanceolate, shorter and narrower than the inner, rounded at the apex, concave, the inner carinate below, plane above; stamens much shorter than the perianth segments, the filaments subulate, glabrous, adnate at the base to the perianth segments, the anthers oval, white; styles 3, slender, free, recurved; stigmas capitate; fruit triangular and flask-shaped, the much inflated base being expanded into three prominent lobes, abruptly contracted at the middle into a sharply triangular upper part, sparingly short-hairy when young.

Type in the U. S. National Herbarium, no. 1,631,285, collected in Titus Canyon, Grapevine Mountains, Death Valley, Inyo County, California, at about 2,000 feet altitude, Oct. 13, 1935, by M. French Gilman (no. 2120).

The following additional specimens, all from Death Valley, have been examined: Same locality, Apr. 25, 1932, *Coville & Gilman* 442; May 8, 1934, *Gilman* 1194; June 11, 1935, *Gilman* 1690. Death Valley Canyon, July 9, 1935, *Gilman* 1917. Also several unnumbered specimens collected in Titus Canyon by Mr. Gilman to show the articulations of the old stems.

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PHYSICAL CHEMISTRY.—*Solubility in the system, $KCNS$-H_2O.*[1]

F. C. KRACEK, Geophysical Laboratory, Carnegie Institution of Washington.

In continuation of studies on solubilities in aqueous solutions at relatively elevated temperatures by the method of sealed tubes[2] it became desirable to re-design the apparatus for greater convenience and reliability. In testing out the new apparatus, the solubility of potassium thiocyanate in water was determined over the range extending from room temperature to its melting point. Reasons for selecting this salt were its relatively low melting point and rapid solubility. Unfortunately, the solubility has never been studied at temperatures above 25°C., so that no data exist for comparison at the higher temperatures. Furthermore, there are no thermal data on this compound available, with the sole exception of a calculation by P. W. Bridgman[3] of the heats of fusion and of a polymorphic transition, based upon P-V results at high pressures. The values given are 10.3 and 1.325 mkg/g, the extrapolated melting point and inversion point being given as 171.2° and 140°C. respectively.

EXPERIMENTAL

Materials. Reagent grade KCNS was further purified by recrystallization. The salt was dried at a temperature above the transition point, but below the melting point, in vacuum. No appreciable decomposition was noticed, except when the salt was heated above the melting point with free access of air. The melting point of the purified product was 176.8° ±0.1°C., and differed only a little from that of the dried commercial reagent. The transition temperature, 140.6° ±0.1°C., was unaffected by purification. The transition is remarkably prompt in either direction.

Apparatus. A well constructed air-bath thermostat was employed. In principle, this is a copper lined muffle furnace of rectangu-

[1] Received June 26, 1936.

[2] F. C. KRACEK, J. Phys. Chem. **35**: 417, 947. 1931; J. Am. Chem. Soc. **53**: 2609. 1931.

[3] P. W. BRIDGMAN, Proc. Am. Acad. Arts Sci. **51**: 55. 1915.

lar cross-section, open at both ends, the muffle cross-section being 16.5×10 cm. The interior of the muffle is provided with an air propeller, and with a slowly revolving holder for the solubility tubes. The shafts carrying the propeller and the tube holder enter the muffle at the centers of the two side walls, being supported on graphite bearings (which need no lubrication) at the muffle ends, and on ball bearings at the outer ends. The end openings of the muffle are closed by removable glass doors which permit observation of the progress of the experiment. Three thicknesses of glass, providing two heat-insulating air spaces in series at each end, have been found to give adequate protection against disturbances of the temperature distribution.

The muffle, constructed of heavy *transite* board, is lined with copper plates *ca.* 6 mm thick. It is wound with approximately 16 ohms of No. 15 B. and S. gauge nichrome wire. The temperature attainable on 110 v. current is well above 600°C. The regulation of the temperature is provided for by a five-junction copper-constantan thermoelement operating a sensitive potentiometer controller. The hot junctions of the thermoelement are cemented to the muffle immediately outside the winding, but electrically insulated from it; the cold junctions are kept in melting ice. The rapid response of the thermoelement to changes in temperature of the winding, together with the rather large heat capacity of the muffle, and the high thermal conductivity of the heavy copper lining serves to provide satisfactory thermostatic operation. Exploration of the interior of the thermostat with a bare junction of a copper-constantan thermoelement showed that the temperature distribution is uniform to within 0.05°C. (with the air propeller in motion). The deviations from uniformity actually are momentary fluctuations, which for purposes of measurement are smoothed out by enclosing the measuring junction in a small bore copper tube. The temperatures as measured by the enclosed junction are found to be uniform, and constant to within ± 0.01°C., which is sufficiently precise for the present purpose.

Procedure. Weighed quantities of purified KCNS and of pure water are sealed in Pyrex tubes of *ca.* 10 mm inside diameter, 12–15 cm long, and of 1 mm wall thickness. These tubes withstand a considerable internal pressure; in the present investigation the vapor pressures of the solutions are always low, and hence there was no danger from explosions. No corrosion of the tubes by the solutions could be detected.

The sealed tubes are rotated in the thermostat until all the crystals dissolve, as judged by visual observation. Owing to the destruction of nuclei on complete dissolution, the equilibrium can not be approached from above. This actually causes only a slight inconvenience in testing for the equilibrium temperature. If one or two crystals are present and the temperature is slightly lowered, then (a) if crystals begin to grow at once, the previous temperature was below the liquidus, while if (b) new crystals do not form, the temperature may still be above the liquidus, and more time must be given for the attainment of equilibrium, or (c) there may be a difficultly soluble impurity present. After complete dissolution, the undercooling in this system was usually 3° to 4° (Miers' supersolubility limit). It will be obvious that a solubility determination by this method consists of establishing, with as good approximation as may be necessary, the temperature at which the last crystal disappears in equilibrium with the solution. It is wholly analogous in principle to the quenching method so extensively used in this Laboratory for the study of equilibria in silicate systems.

The Experimental Results. Measurements of the solubility temperatures were made for compositions from 72.61 to 100 weight percent KCNS. The data obtained, together with a résumé of previously available determinations, are collected in Table I. The compositions are expressed in two ways: (1) in weight of salt per 100 g of water, which is the most suitable method for practical purposes, and (2) in mole percent (100 times the mole fraction) of salt, for theoretical purposes. In calculating the mole fractions an assumption must be made concerning the mole weights of the components in solution, or more exactly, concerning the *ratio* of the mole weights. The common practice is to assume the stoichiometric molecular weights. Other mole fractions may be computed, based on an *effective* mole weight ratio. The mole percent compositions listed in Table I are the stoichiometric values, based on 97.168 for KCNS and 18.0154 for water.

The solubility curves for KCNS in water can be expressed by means of empirical equations of the type

$$\log(100N_2) = a + \frac{b}{T} + c\log T + dT + \cdots \tag{1}$$

where N_2 is the mole fraction of KCNS, a, b, c $\cdots$ are empirical

Table I.—Solubility of KCNS in Water

Expt.	g KCNS per 100 g Water	Mole % KCNS		Liquidus t°C.	Solid Phase
		Exptl.	Calcd.		
—	—	100.00	—	176.8	KCNS I
27	11961	95.69	95.56	170.7	"
5	9342	94.55	94.60	169.2	"
22	5773	91.46	91.47	164.5	"
21	4185.8	88.59	88.58	160.0	"
3	3599.6	86.97	86.97	157.4	"
2	3116.2	85.25	85.52	155.0	"
6	2471.1	82.08	82.23	149.4	"
7	2188.2	80.23	80.33	146.1	"
8	1957.7	78.40	78.50	142.7	"
9	1825.6	77.19	77.35	140.6	KCNS II
1	1476.1	73.24	73.24	133.9	"
10	1346.2	71.40	71.40	130.7	"
11	1150.2	68.08	68.00	124.6	"
12	956.6	63.94	63.90	116.8	"
13	802.9	59.82	59.80	108.4	"
14	673.6	55.53	55.53	99.0	"
15	526.9	49.42	49.45	84.2	"
20	455.90	45.81	45.83	74.5	"
16	408.45	43.09	43.12	66.7	"
19	358.60	39.93	39.94	57.0	"
17	317.05	37.02	36.92	47.3	"
18	265.10	32.95	32.73	32.6	"
(3)	239.0	30.70	30.70	25.0	"
(4)	217	28.7	29.41	20	"
(4)	177	24.7	24.52	0.0	"
(5)	101	15.8	17.64	−31.2	"

(3)—H. W. Foote, Z. physik. Chem. **46**: 79. 1903.
(4)—F. Rüdorff, Ber. **2**: 68. 1869.
(5)—A. Vasilijev, J. Russ. Phys. Chem. Soc. **42**: 423. 1910.

constants and T is the absolute temperature of the liquidus. The corresponding slopes are given by

$$(2)\qquad \frac{d}{dT}\log(100N_2) = -\frac{b}{T^2} + 0.4343\frac{c}{T} + d + \cdots.$$

Because of the polymorphic inversion at 140.6°C., two equations must be used to express the solubility. The constants of the equations derived from the experimental data are as follows:

(a) For KCNS I, valid from the transition point (140.6°) to the melting point (176.8°),

$$a = -\ 20.71904$$
$$b = 892.459$$
$$c = 7.81532$$

(b) For KCNS II, valid at temperatures below the transition point,

$$a = 31.85576$$
$$b = -957.918$$
$$c = -12.27825$$
$$d = 0.0108207$$

The (metastable) melting point of KCNS II, calculated from the (b) constants, is 171.6°C.

The computed values of the compositions are included in Table I for comparison with the experimental. The principal discrepancy between observed and calculated values is in the composition of the cryohydric point, for which Vasilijev determined a composition corresponding to 15.8 mole percent KCNS, whereas the calculated value is 17.64, at −31.2°C.

The results are graphically illustrated by Fig. 1.

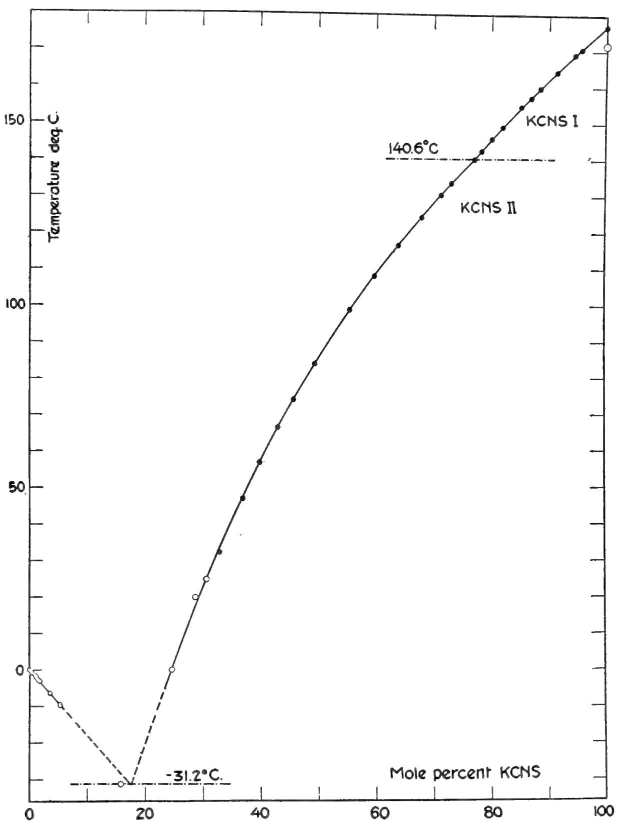

Fig. 1.—Equilibrium diagram for KCNS-H_2O. Black dots, present investigation. Open circles, previous data. Open circle at 171.6°, 100% KCNS represents the (metastable) melting point of KCNS II, extrapolated by use of equation (b).

DISCUSSION

Gibbs' theory of heterogeneous equilibria leads to the following general expression for the effect of temperature on the solubility in binary systems at constant pressure:

$$\frac{d}{dT}\ln N_1''=\frac{N_1'(S_1''-S_1')+N_2'(S_2''-S_2')}{\dfrac{N_1'-N_1''}{1-N_1''}\left(\dfrac{\partial\mu_1''}{\partial\ln N_1''}\right)_{p,T}} \tag{3}$$

all the symbols having their usual significance, μ and S being (partial) specific or molal quantities, depending on whether N is in weight or mole fractions, respectively. The double accents refer to the solution, the single accents to the dissolving phase. The expression for the other component is symmetrical with (3) merely by interchange of subscripts. When the dissolving phase is the pure component 2, ($N_2'=1$, $N_1'=0$), we may write

$$\frac{d}{dT}\ln N_2''=\frac{H_2''-H_2'}{RT^2\dfrac{1-N_2''}{1-N_2''}\cdot\dfrac{N_2''}{RT}\left(\dfrac{\partial\mu_2''}{\partial N_2''}\right)_{p,T}}. \tag{4}$$

Converting to common logarithms and equating expressions (2) and (4) we obtain, further, that

$$\frac{N_2''}{RT}\left(\frac{\partial\mu_2''}{\partial N_2''}\right)_{p,T}=\frac{H_2''-H_2'}{4.578(-b+0.4343\,cT+dT^2+\cdots)} \tag{5}$$

where b, c, $d\cdots$ are the empirical constants evaluated from the solubility curve values, and $(H_2''-H_2')$ is the heat absorbed by the system when a unit quantity (1 mole in this case) of the dissolving phase goes into solution reversibly in the saturated solution whose composition is N_2'' at the absolute temperature T.

In the absence of all thermal data on KCNS and its solutions, we are limited to evaluation of equation (5) solely for the case $N_2''=1$, where $(H_2''-H_2')$ is equal to the molal heat of fusion of KCNS. This we obtain from the calculations by Bridgman (op. cit.) whose values become, in cal/mole, equal to 2345 for KCNS I (above the inversion temperature) and 2647 for KCNS II (neglecting temperature coefficients of $(H_2''-H_2')$).

Substituting the appropriate numerical values for the constants in equation (5) from (a) and (b), and the corresponding numbers for the melting points of the two modifications (176.8° for KCNS I, and

171.6°, obtained by extrapolating (b) to 100 percent KCNS, for KCNS II), we obtain

$$\frac{N_2''}{RT}\left(\frac{\partial\mu_2''}{\partial N_2''}\right)_{p,T}=\frac{2345}{2961}=0.795 \text{ for KCNS I,}$$

$$=\frac{2647}{3326}=0.796 \text{ for KCNS II.}$$

The concordance of these two values is better than would be expected on the basis of the experimental data, for while the empirical equations (a) and (b) represent the data without a very pronounced trend of errors in either positive or negative direction, the slopes of the curves are much less accurately known, and it is probable that only an accidental compensation of errors leads to the computed close agreement between these two numbers; particularly so, since Bridgman himself states "It is especially to be noticed that the values [of ΔH and ΔE] given for the melting curve are only approximate; since no great effort was made to get these very accurately."

SUMMARY

Solubility of KCNS in water was studied from room temperature to the melting point of the salt (176.8°C.). KCNS undergoes a rapid polymorphic inversion at 140.6°C.; consequently, the solubility curve has a break at this temperature. The two branches of the curve can be represented by the equations:

(a) $\log(100N_2)=892.459/T+7.81532\log T-20.71904$

valid between 140.6° and 176.8°C., and

(b) $\log(100N_2)=-957.918/T-12.27825\log T+0.0108207T+31.85576$

valid below 140.6°C.

PALEOBOTANY.—*Plant distribution as a guide to age determination.*[1]

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The determination of age of rock layers is one of the important objectives of the paleontologist and geologist. While many other considerations are of equal significance, it is clear that chronology—the establishment of the age or relative age of geologic formations—is a primary necessity.

Of the several lines of evidence used by the stratigrapher in deter-

[1] Received May 26, 1936.

mining the age of sedimentary rocks, there are two which may be of relatively little value to the student of Cenozoic paleobotany in western America: the vertical sequence of beds, and the stage of phylogenetic development of the fossils contained in them. A large number of occurrences of Cenozoic plants are in terrestrial deposits limited in areal distribution, and stratigraphically unrelated to underlying formations. There is comparatively little evidence of phylogenetic change among the angiosperms and conifers which make up the bulk of the plant record since the Cretaceous. It is therefore necessary for the paleobotanist to recognize and interpret another trend through later geologic time, a sequence involving changes in distribution.

There is general agreement among students of land life, both of the present and of the past, that changes in distribution are brought about by changes in living conditions. In other words, migrations do not result from any inherent tendency on the part of land plants, or of animals, to wander, but are the result of compulsion. Changes in topography, resulting from diastrophism, vulcanism and gradation, so alter environments as to compel the shifting of populations. Changes in climate, due to terrestrial or solar causes, force plants and animals to move over wide ranges of latitude. Alternatives to such migrations are extinction, or changes in habit or structure. All three of these results of dynamic physical control are apparent in the record of Cenozoic plant life in western America.

It may be assumed that so long as the earth has received the major part of its energy from the sun, and that so long as the continents have occupied their present positions, the factor of latitude has been of critical importance in determining the life of any region, and in establishing climatic differences between areas near or distant from the equator. The assumption of cosmopolitan floras and faunas on the land during the past tends to disregard the effects of difference in latitude upon life. Such an assumption is justified only when a considerable length of geologic time is involved, during which groups of plants and animals covered wide areas as a result of climatic change. The periods of the Cenozoic are so short relatively, and our information regarding their life is so relatively complete, that any literal application of the term "cosmopolitan" to fossil floras is highly misleading.

Evidence will shortly be presented for the conclusion that the plant life of any Cenozoic period in western America varied widely at different latitudes, and that altitude and also position with rela-

tion to topographic barriers had a differentiating effect. But it will first be appropriate to outline the general nature of the physical changes during Cenozoic time, from the Great Plains west to the Pacific.

During the opening period of this era, the Eocene, there was a wider transgression of the sea upon the continental borders than at any time since, although the invading seas were less extensive than during earlier eras. The absence of the present Coast Ranges, and the relatively incipient development of the Cascades and Sierra Nevada, resulted in the landward penetration of ocean climate almost to the Rockies. Only this range, which had been uplifted during the Cretaceous, served as a topographic and climatic barrier to the Great Plains at the east. Other factors, including increased solar energy, may have combined to make the climate of western America warmer and more humid than at present. In any case the relative submergence and low altitude of the area west of the Rockies during older Cenozoic time is at least a partial explanation of the subtropical climate indicated not only by the plants (1) but by the invertebrates and by the mammals (2). A more general circulation of air and of ocean currents, and possibly the cutting off of the Pacific Basin from the Arctic by the land connection between Siberia and Alaska, brought a climate to Oregon and California much like that in Mexico and Central America at the present time.

The nature of the older Cenozoic floras on the Pacific Coast has been described by the writer and his associates (3) and need not be considered in detail at this point. They are composed of broad-leafed evergreens, of which dicotyledons predominate, with subordinate elements of monocotyledons, conifers and ferns. Of the families represented, many are exclusively tropical in their present distribution. A majority of the genera are confined to low latitudes, or have their best development there. Such genera as *Allophylus*, *Calyptranthes*, *Cinnamomum*, *Cordia*, *Ficus*, *Lonchocarpus*, *Meliosma*, *Oreopanax*, *Persea*, *Sabalites* and *Tetracera* are represented by species whose modern equivalents occur in Mexico and Central America, or to a lesser extent in paleotropical regions. The characters of the leaves, especially their size, shape and texture, are suggestive of plants now living in the warmer parts of the world. The high tree-shrub ratio, and the relative abundance of vines, also suggest subtropical vegetation. Although the record is composed largely of leaf impressions, fossil wood and fruiting structures are gradually becoming available as a means of corroborating generic determinations.

Associated with these subtropical plants are other genera which are at present more wide-ranging in distribution, such as *Cornus, Magnolia, Platanus, Quercus, Ulmus* and *Viburnum*. Their occurrence with the more tropical types of plants has some parallel in the Mexican forests of today, and is suggestive of climatic conditions at lower to medium altitudes on the borders of the American tropics. Although quantitative estimates can be only approximate, the older Cenozoic vegetation of the western United States seems to require a climate having a mean annual temperature between 65 and 70°F., and a rainfall of not less than 70 inches a year.

The gradual withdrawal of the seas from the continental margins is indicated by the sequence from marine to terrestrial deposits in the Eocene and Oligocene systems of Oregon. The locally active upbuilding of mountain ranges, which reached its climax in the Pliocene, combined to bring about changes in climate which resulted in marked alterations in the vegetation. In favorable situations along the Pacific Coast, *Tetracera* and *Meliosma* lingered into the Middle Oligocene of northwestern California (4), and *Ficus, Oreopanax* and *Persea* survived into the Upper Miocene in central and southern California (5). But for the most part the subtropical elements of the Eocene forests were gradually eliminated from temperate latitudes by Middle Cenozoic time, due to reduced winter temperatures and lessened precipitation as imposed by continental climates on an emerging land mass.

Over a wide area extending from northern California to Colorado, north to Montana, and coastward to include most of Oregon and Washington, as well as parts of British Columbia, there developed in middle Cenozoic time a temperate forest in which *Sequoia,* of the coast redwood type, was a dominant element. Regularly occurring with it were the Tertiary equivalents of several common associates of the living redwood, of which the alder (*Alnus carpinoides*), tanoak (*Quercus consimilis*) and bay laurel (*Umbellularia oregonensis*) are the most common (6). In this redwood forest of the Miocene, there was also a group of broad-leafed deciduous trees which no longer live in western America, although they have survived in forests of somewhat similar types in the eastern United States and northeastern Asia. This group, including such genera as *Carpinus, Castanea, Fagus, Ostrya, Tilia* and *Ulmus,* has higher summer rainfall requirements than are afforded by the present climate of western America. It seems possible to assume that the conditions which now bring summer drouth on the Pacific Coast were not operative during the Miocene. Several genera occurring in the Miocene redwood forest

are now confined to Asia; *Cercidiphyllum* and *Ginkgo* are examples. Numerous specific resemblances, in such genera as *Castanea*, *Crataegus*, *Quercus*, *Rhus* and *Ulmus*, are close between trees of the American Miocene and those now living in China and Japan. Notwithstanding these exotic elements, the redwood forest of the middle Cenozoic had much the same general aspect as the modern forest of the California coast, as shown by the dominance in it of species corresponding to those most abundant today.

While *Sequoia* survived into the Upper Miocene forests of western America, it yielded its position of dominance to a group of genera which now occupy relatively exposed situations on the borders of the redwood forest. Black oak (*Quercus pseudo-lyrata*), live oaks (*Quercus simulata* and *traini*), maples (*Acer merriami* and *negundoides*), madroño (*Arbutus matthesii*), plane tree (*Platanus dissecta*), and such conifers as *Pseudotsuga*, *Abies* and *Pinus* make up the conspicuous trees of this younger forest (7). From the occurrence of the modern equivalents of these trees in a relatively cool and dry habitat, it has been concluded that further climatic changes had taken place since the Lower Miocene. A physical basis for such changes may be found in the increasing uplift of the Cascades, and the widespread vulcanism in this and adjacent regions during later Miocene time.

Less well known than the Miocene and Eocene floras, the vegetation of the Pliocene shows even more strikingly the effects of continued uplift. Over the wide area east of the Cascades, fossil plants are absent, so far as known, from the record. It is reasonable to suppose that the redwood was completely eliminated by the growing climatic barrier, and that other forests were limited in distribution. To the south, a modified redwood forest, with dominant oaks and *Pseudotsuga*, occupied the area adjacent to the ocean. But inland, where the effects of the sea were greatly lessened due to the building of mountain barriers, the vegetation is limited to poplar, willow, plane tree and other stream-border types, most of which still survive (8). A general trend from a warm, moist climate in the Eocene to a cool, dry climate in the Pliocene is therefore established by the fossil plant record. The physical conditions in the Pleistocene are also consistent with this thesis, but since floras of that age are limited in extent and contribute only confirmatory data to it, they will not be discussed here.

It seems desirable to emphasize at this point the rather obvious fact that most plant remains have been accumulated in sediments at low altitudes. There are occasional exceptions, but the great majority

of Cenozoic floras are made up largely of lowland species, with rarely any conspicuous element brought in from great distances. Widely transported material, in the form of wind-transported pollen grains or winged seeds, or of water-transported wood and cones, can commonly be recognized as being introduced from outside, because of its scarcity or worn condition. In most cases, the fossil record is made up of remains of plants which lived in close proximity to the areas of deposition along rivers, lakeshores or embayments. The sequence of Cenozoic floras is therefore a record limited almost entirely to the vegetation of the lowlands, and the climate and other physical conditions indicated by plant fossils are also those of areas near sea level.

In order to reconstruct an upland setting and the forest which occupied it, several assumptions may be made which are based on modern forest distribution. During the middle Cenozoic, when a redwood forest, commonly known as the Bridge Creek flora, occupied the lowlands of the John Day Basin and adjacent Oregon, it is reasonable to suppose that there was a forest on adjacent ridges and valley slopes which was less mesic in character. Such a forest, made up of life oaks, madroño and Douglas fir, is today characteristic of the borders of the redwood forest. This forest has its Cenozoic equivalent in the Mascall flora which followed the Bridge Creek flora in the John Day Basin of Oregon, and elsewhere in western America. It reflects an increasing uplift of the Cascades and the establishment of a relatively continental climate on their eastern and leeward side in later Miocene time.

In like manner, the Bridge Creek flora, recorded in sediments of late Oligocene or early Miocene age, may be assumed to have covered the more exposed habitats during Eocene and older Oligocene time, when the lowlands were occupied by a subtropical forest in which broad-leafed evergreens predominated. In the modern forests of Mexico and Central America, the lowland forests up to altitudes of approximately 4000 feet are essentially of the older Cenozoic type. They contain most of the genera which have been recorded from the Eocene and older Oligocene of the western United States, and are subtropical in aspect. On the higher slopes, and especially well-developed at altitudes around 7000 feet, the vegetation is temperate. A large number of the genera are among those listed from the middle Cenozoic, although *Sequoia* is missing and its place is taken by *Pinus*. Here, within a small area and separated only by differences in altitude, are two readily distinguishable forests whose fossil equivalents occur in the Eocene and in the Miocene of the western United States.

The possibility of a mixture of leaves from these two forests in contemporary deposits is slight, since the temperate forest is on upper slopes several miles distant from sites of deposition. Such leaves as are accumulating at the present time are of the subtropical, Eocene type. The upper forest, of a temperate and Miocene aspect, will doubtless be absent in the record of contemporary sediments in the same way that upland floras are unrepresented in the record of the Cenozoic.

A second method of determining the nature of upland vegetation during the past is to establish floristic relationships between two essentially contemporaneous floras at different altitudes and latitudes. Just as the modern forests of high altitudes have closely similar equivalents near sea level at higher latitudes, so the upland forests of the past may be reconstructed by a survey of contemporaneous fossil floras to the north. In such comparisons, the contemporaneity of the floras is not reflected by any close similarity in the plant assemblages. It might even be said that if a flora from Oregon was closely similar in composition to one from Alaska, the age of the two must be different. A separation in latitude of 20 degrees may be expected to have involved, in the past as at the present time, the development of plant assemblages of wholly distinctive composition. For the establishment of contemporaneity between such Eocene floras as the Kenai of Alaska and the Comstock of Oregon, it is necessary to depend upon other evidence of equivalence in age, such as the invertebrates, or the stratigraphic and structural relations of the associated beds.

When the Eocene floras of Alaska and of other high latitudes were first studied by Heer, it was assumed that they were of Miocene age because of their similarity to the Miocene vegetation of middle latitudes. Subsequently it was pointed out by Gardner (9) and others that the Eocene floras of high latitudes migrated southward to occupy middle latitudes during the Miocene period. This involved the concept of an holarctic center of distribution, an assumption which has been amply supported by evidence of fossil plants and mammals accumulated during the 57 years since Gardner made this statement. The close resemblance of the Kenai flora from the Eocene of Alaska to the Bridge Creek flora from the Upper Oligocene or Lower Miocene of Oregon fully supports the idea of a migration southward during the Cenozoic.

Since a temperate forest with redwood and broad-leafed deciduous trees was present at low altitudes in high latitudes during the Eocene,

it is reasonable to assume that a similar forest may have occupied higher altitudes in middle latitudes at this time. In other words, a situation similar to that described in the mountains of modern Mexico may be considered to have existed in Oregon and adjacent areas during the Eocene. A subtropical forest at low altitudes contributed leaves and other structures to the sedimentary record, where they have been preserved as fossils; but the temperate forest occupied altitudes so high that few if any of its representative elements entered the sedimentary record.

To many stratigraphers, the concept of a "Miocene" forest on the ridges or at high latitudes during the Eocene period is highly distasteful. Such a situation has given rise to the conclusion that Cenozoic plants are without value as time indicators. This is admitted as frequently the case, except as the latitude of the fossil plant occurrence is taken into consideration. But with an established climatic trend, based upon a known physical history of emergence and orogeny, the position of a Cenozoic flora with reference to the equator may indicate its position in the stratigraphic column as accurately as can the stage of evolution of a mammal or a mollusc.

It is not within the province of this paper to discuss the application of the idea of distribution in time to the invertebrate and vertebrate record.[2] The suggestion may be made, however, that it may be useful in some cases. Where a wide transgression like that of the early Paleozoic is involved, or the dispersal of such a genus as *Hipparion* over several continents, it seems possible that many of the disagreements among paleontologists regarding the time range of animals in the past may be solved by fuller knowledge of their centers of distribution and of their migration routes. When periods as long as those of the Paleozoic are involved, time designations as exact as those suggested for the Cenozoic may not be required, and the recognition of faunas in more general terms may be satisfactory. If it were sufficient to speak of a flora as of "Tertiary" age, the necessity would not exist for determining its changing geographic position from Eocene to Miocene time; it would be sufficient to designate the temperate redwood flora in these general terms, without regard for the fact that tens of millions of years were involved in the physical events which led to its southward migration from Alaska to Oregon. But such a characterization of this flora would involve not only a loose time con-

[2] See Matthew, W. D., *Climate and Evolution*, Ann. N. Y. Acad. Sci. **24**: 171–318, 1915, for a critical statement of space relations involving vertebrates.

cept, but would leave many of the most critical aspects of earth history out of consideration.

With careful application, intercontinental correlations based on Cenozoic floras carry much weight if both occur at similar latitudes. But there are other factors which must be taken into consideration. One of these, the factor of altitude, is and has always been of great importance in determining the nature of vegetation. Its actual significance in paleobotanical studies is lessened by the fact that only a comparatively small proportion of upland plants permanently enter the fossil record. Another factor in the interpretation of the climate-distribution-age significance of a fossil flora is its position with relation to topographic and climatic barriers. The effect of the modern Cascade Range on the vegetation of eastern Oregon is striking; two wholly different plant associations occupy its western and eastern slopes. The uniformity of the middle Cenozoic redwood forest from western to eastern Oregon is interpreted as indicating that this barrier was not then in existence. Resemblances between the Eocene floras of Oregon, the Comstock in the western and the Clarno in the eastern part of the state, are so marked that the absence of any high intervening mountains during early Cenozoic time is indicated. Farther to the east, however, the Eocene floras of the Interior Province show the effects of the upbuilding of the Rocky Mountains during the Cretaceous period. Evidence of a climate less warm and moist than that bordering the Pacific may be recognized in the subordination of the subtropical element, and in the greater abundance and diversity of temperate genera. Such differences reflect divergent habitats rather than age discrepancies.

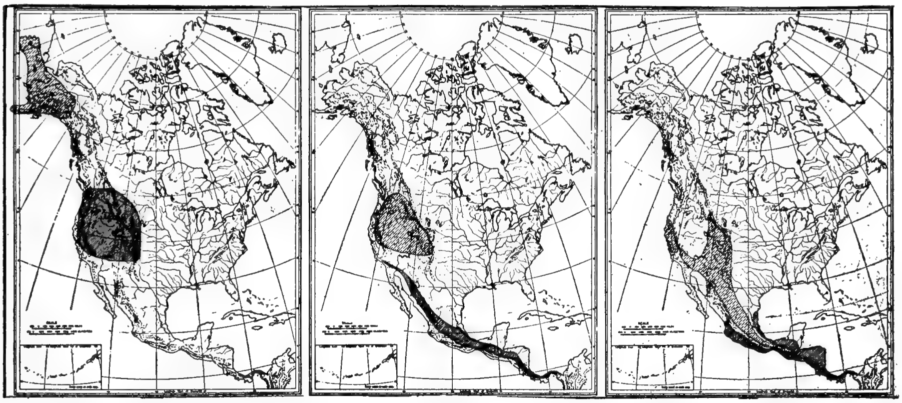
The practical value of such considerations as latitude and climatic barriers in age determination is illustrated by the recent study of a flora from Beaver County, Oklahoma (10). It is made up largely of plants related to those of the Miocene floras of the Rocky Mountain and Columbia Plateau provinces, and although redwood is missing, the usual procedure would have been to assign it to the Miocene. The association of a mammalian fauna, in which well-defined horses and beavers indicated Lower Pliocene age, raised objections to such an age reference. A study of the diatoms also indicated post-Miocene age. Here was a setting for another disagreement based upon divergent testimony of different lines of evidence.

It will be sufficient to state that an analysis of the Beaver County flora on the basis of its geographic occurrence also indicated its Lower

Pliocene age. The elimination of *Sequoia* and other mesic Miocene genera, and the increased abundance of stream-border trees such as poplar and hackberry, was in line with the occurrence of this flora on the High Plains east of the climatic barrier interposed by the Rocky Mountains. The position of the flora 500 miles south of the area in which the related Mascall flora is recorded, was consistent with its post-Miocene age, since a considerable time interval might be expected to have been involved in its migration southward. The concept of a climatic trend, resulting from continental uplift, and causing the movement of forests toward the equator during the Cenozoic, made possible the reference of a flora, which was "Miocene" in terms of its Oregon relationships, to the Pliocene period in Oklahoma.

This use of space relationships as a guide to floral age may be open to the criticism that the trend toward emergence in western America during the Cenozoic did not proceed continuously, and that there may have been reversals in the resultant climatic trend which would throw into error any conclusions based upon the physical significance of vegetation. To such criticism the reply may be made that conclusions based on the space-time relationship of floras in the Tertiary of western North America, so far as they have been made, are in accord with the evidence of fossil vertebrates and invertebrates, and with the stratigraphic sequence in so far as it is fully understood. If the climatic trend from the Clarno to the Bridge Creek and Mascall floras of the John Day Basin was not in accord with the sequence of these beds from older to middle Cenozoic, as established by Merriam 35 years ago (11), and if the evidence of the associated mammals was not consistent with the floral conclusions both as to age and environment, it is clear that conclusions based upon plant migrations would be open to doubt. The sequence of Tertiary floras, to which this climatic trend has been aligned, has however been verified in accord with all lines of evidence available in eastern Oregon. With this area as a point of departure, it is proving possible to judge the age of related floras on the basis of their geographic occurrence elsewhere. If inconsistencies are found when these studies overlap into areas where marine deposits are intercalated with those of the land, revision of criteria employed by both the paleobotanist and the invertebrate paleontologist may be necessary. It is only through the use of all possible lines of evidence that the true sequence of events may be determined and their full significance in terms of earth history understood.

It seems desirable to illustrate graphically the change in position of Cenozoic floras in western America as they are known from the data now available. Fig. 1 shows the distribution of the subtropical and temperate forest units during the early part of the era, at its middle, and in modern time. From an area extending from central California north into Washington, eastward into Montana, and south to New Mexico at the beginning of the Tertiary, the subtropical forest was shifted into southern California and the mountains of Mexico during the Miocene, and subsequently to the lower altitudes



A B C

Fig. 1.—Showing distribution of subtropical and temperate forest units during the Cenozoic of western America. A, Eocene; B, Miocene; C, Recent. In all maps, closely spaced continuous lines indicate a subtropical, and broken lines a temperate forest.

of Mexico and Central America where it is now found. From Alaska, extending across into Siberia, in Eocene time, the temperate forest was shifted to middle latitudes during the Miocene. It is now broken up into various units, of which the dominant coast redwood forest has survived only along the coast from Oregon to central California, with elimination of many of the broad-leafed deciduous genera. Many genera of this temperate forest have survived also in the forests of the Cordillera, especially in the mountains of Mexico and Central America. A study of the distribution of this modern vegetation throws much light on the climatic history and the stratigraphic sequence of the Cenozoic rocks in western North America.

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ZOOLOGY.—*Notes on the Crustacea, chiefly Natantia, collected by Captain Robert A. Bartlett in Arctic Seas.*[1]

MARGARET E. VAN WINKLE, Wellesley College, and WALDO L. SCHMITT, U. S. National Museum.

Nearly every year for more than a decade Captain Bartlett has brought back a veritable zoological treasure trove to the United States National Museum. Some portions of his extensive collections have been reported upon by various specialists in this Journal, in the Proceedings of the National Museum, and in the Smithsonian Miscellaneous Collections. Here for the first time, however, is assembled a complete list of his decapod crustacea, together with some casual notes on a few other forms. The specimens listed were taken in each of the years 1924 to 1935, inclusive, with the exception of 1928 and 1934, when Captain Bartlett and his schooner, the *Morrissey,* were under exclusive contract to other parties.

Of particular interest are the collections made in Fox Channel, Fox Basin, and the Straits of Fury and Hecla north of the Melville Peninsula. The only decapod crustacea previously recorded from these waters were five in number, secured by the second Parry Expedition in the *Fury* and *Hecla,* for which the Straits were named, in the fall of 1822. These species were taken in nets off Igloolik

[1] Received April 2, 1936.

Island, the winter quarters of that year, where they were said to have been "found abundantly," or "taken in considerable numbers." These particular decapods are *Spirontocaris groenlandica*, *S. polaris*, *S. spinus*, *Sabinea septemcarinata*, and *Sclerocrangon boreas*.[2]

Captain Bartlett also obtained the same species at several stations in the same general neighborhood, with the exception of *Sabinea septemcarinata*. Indeed, two of the species, *Spirontocaris groenlandica* and *S. spina*, were caught in the entrance of the Straits at a point a little farther north than Igloolik Island, together with two other decapods not seen by the earlier expedition: *Spirontocaris phippsii* and *S. gaimardii*. *S. gaimardii belcheri* and *S. fabricii*, which were dredged by Captain Bartlett at several stations, had also been missed by the Parry Expedition, as had *Pagurus krøyeri*, which Captain Bartlett collected off Igloolik Island.

The bulk of the decapod material of the 1929, 1930, and 1931 expeditions, amounting to over a thousand specimens, was determined by Mrs. Van Winkle, of the Department of Zoology of Wellesley College. The second author undertook the balance of the material not otherwise credited. We are indebted to Dr. Mary J. Rathbun for naming the several species of brachyura, while the identifications of the amphipods cited in connection with the crustacea found in seal and codfish stomachs were furnished by Clarence R. Shoemaker, whose complete report upon the amphipods is reserved for a later date.

In order to add to our knowledge of the distribution of the species discussed in this paper, brief reference has also been made to crustaceans that were named for the Biological Board of Canada and which had been secured under its auspices during a series of biological and fisheries surveys carried on in Hudson Strait and Hudson Bay in the years 1927, 1928, and 1930.

For conciseness, the localities from which the Bartlett crustacea listed below were collected are referred to by number in the manner suggested by Austin H. Clark in his report upon the Bartlett echinoderms (this Journal 26: 294). For more ready reference, these lo-

[2] Ross, James Clark. *Marine Invertebrate Animals*, in Appendix, Jour. . . . Third Voyage . . . Discovery . . . Northwest Passage . . . , p. 120, London, 1826; and in Appendix, Narrative . . . Second Voyage . . . Search . . . Northwest Passage . . . , pp. lxxxi–lxxxiv, London, 1835.

Nils von Hofsten, in his masterly treatment of the crustacea of Eisfjord, Spitzbergen (Kungl. Sven. Vet. Akad. Handl. **54** (No. 7). 1916), depicts the Ross finds, among others, on a series of charts showing the polar distribution of each of these five species, with the exception of *S. groenlandica*. On the distribution chart of this species the Igloolik record established by Ross appears to have been inadvertently omitted.

calities are arranged in five groups lettered A to E. Within their respective groups the localities have been arranged, so far as possible, in order of latitude from south to north, without regard to longitude or date.

Localities at which crustacea were dredged, unless otherwise indicated, are as follows:

A. LABRADOR COAST. 1. Saglek Bay, September 25, 1925. 2. Kamaktorvik Bay, 59° 31′ N., 63° 50′ W., July 12, 1929. 3. Coast of Labrador, August and September, 1925.

B. FOX CHANNEL AND FOX BASIN, BAFFIN LAND, AND MELVILLE PENINSULA. 4. Four to five miles east of Cape Dorchester, August 8, 1927, 25 fathoms. 5. West end of White Island, Comer Straits, August 10, 1933. 6. Hurd Channel, between Bushman Island west of Vansittart Island and Melville Peninsula, August 10, 1933. 7. Between two unnamed islands south of Cape Martineau, east of Duckett's Cove, August 19, 1933, 7–15 fathoms. 8. Three stations in Duckett's Cove, Hurd Channel, August 11–13, 1933, 1–14 fathoms. 9. Cove, north shore of Lyon Inlet, August 24, 1933, shore collecting, low tide. 10. Four stations in Fox Basin between 66° 30′ N.–66° 46′ N. and 79° 15′ W.–80° 07′ W., August 10–13, 1927, 32–37 fathoms. 11. Bight, Cape Penrhyn, August 31, 1933, 11 fathoms. 12. Fox Basin, 67° 45′ N., 79° 09′ W., August 24, 1927. 13. Center Fox Basin, August 24, 1927, 25 fathoms. 14. Between Ooglit Islands and Eskimo village at Pingitkalik, September 5, 1933. 15. Two short dredge hauls in entrance to Straits of Fury and Hecla, September 3, 1933, 20–30 fathoms.

C. BAFFIN BAY, ELLESMERE LAND, AND WEST GREENLAND. 16. Three stations, southeast end of Cobourg Island, 75° 40′ N., and between 78° 50′ W. and 78° 56′ W., August 3–4, 1935, $2\frac{1}{2}$–18 fathoms, gravel-rocky bottom, surface temperature 38–39° F. 17. Two stations south end of Cobourg Island, 75° 40′ N., 78° 58′ W., August 4, 1935, 8–20 fathoms, very rocky bottom surface temperature 36°F. 18. Hudson Bay Company's Post, Ponds Inlet, Jones Sound, August 29, 1926, 10 fathoms. 19. Craig Harbour, Jones Sound, August 26, 1926, 7–20 fathoms. 20. Cape York, 76° 00′ N., August 21, 1926 and August 28, 1932, 7–15 fathoms. 21. Kerkotak, Salvo Island, Melville Bay, August 28, 1932. 22. Parker Snow Bay, 76° 07′ N., 68° 20′ W., July 22, 1926 and July 24, 1935, 5–12 fathoms, muddy bottom. 23. Off Dalrymple Rock, Wolstenholm Sound, July 22, 1926. 24. Saunders Island, Wolstenholm Sound, July 22, 1926, 10–12 fathoms. 25. Two stations, Karnah, Inglefield Gulf, August 14, 15, 1926, 5–20 fathoms. 26. Four stations off Northumberland Island, Whale Sound, August 15–17, 26, 1926, 7–30 fathoms. 27. Two stations off Herbert Island, Whale Sound, July 25, 1926, 4–25 fathoms. 28. Hackluyt Island, Whale Sound, 77° 26′ N., 72° 30′ W., July 30, 1935, 11–20 fathoms, bottom small stones, surface temperature 37°F. 29. Three stations, Murchison Sound, August 19–21, 1926, 17–20 fathoms. 30. Five miles south of Cape Chalon, July 27, 1932. 31. Cape Alexander, Smith Sound, August 26, 1932.

D. EAST COAST OF GREENLAND. 32. Four stations, Angmagssalik, August 30, 1930, August 27–29, 1931, 20 fathoms. 33. Off Cape Stosch, Hudson Land, 74° 04′ N., 17° 50′ W., July 30, 1931, 120 fathoms. 34. Between Clavering Island and Hornes Foreland, July 31, 1930. 35. Clavering

Fiord, August 2, 1930. 36. Pendulum Island, July 20, 1930. 37. Bight Shannon Island, July 29, 1930.

E. BERING SEA AND ALASKA. 38. One and a half miles southeast of Cape Cheerful, Unalaska, August 4, 1924, from stomach of fish taken in 3 fathoms. 39. About 15 miles north of Big Diomede Island, June 14, 1924. 40. Twenty-two miles off Shishmaref Inlet, June 27, 1924, 18 fathoms, ship stationary in ice. 41. Thirty miles off Devils Mountain, June 20, 1924, 16–18 fathoms, mud bottom. 42. Two stations, mouth of Kotzebue Sound, July 10, 1924, 10–17 fathoms, mud bottom, ship drifting in ice.

SPECIES COLLECTED

Pandalus borealis Krøyer. D and C. Taken twice by Captain Bartlett from the stomach of codfish at Angmagssalik, east Greenland, August 27, 1931, remains of two specimens; and at Laxebugt, Disko Island, 69° 19′ 14″ N., 54° 14′ W., fragments of one specimen.

Pandalus goniurus Stimpson. E 39, 41, 42.

Spirontocaris groenlandica (J. C. Fabricius). B 7, 15. C 16, 17, 20, 23, 25, 26, 27, 29, 31. D 32. At Angmagssalik, east Greenland, this species was also found in the stomach of a cod, August 27, 1931.

The Biological Board of Canada had specimens obtained along the western shore of Hudson Bay, north of Churchill in 19 and 42 fathoms, off Mansel Island in 75 fathoms; in Hudson Strait at Nottingham Island and Sugluk Creek: and at Port Burwell, Ungava from cod stomachs.

Spirontocaris polaris (Sabine). A 2, 3. B 4, 5, 7, 8, 9, 10, 11, 13, 14. C 16–23, 25, 26, 27, 29, 30, 31. D 32, 33, 35, 36. Also found in cod stomachs, Angmagssalik, east Greenland, August 27, 1931. In one lot of specimens (B 7) there were no lateral spinules on the epimera of the fourth abdominal somite of one specimen, while another had a spinule on the left side only.

The Biological Board of Canada had received specimens from the southern part of Hudson Bay, 57° 19′ N., 85° 32′ W., from 52 to 54 fathoms; from Hudson Strait at Nottingham Island and Sugluk Creek; and from Wakeham Bay and Port Burwell, Ungava, both dredged and from cod stomachs.

Spirontocaris microceros Krøyer. A 1. Two specimens of good size were collected by Captain Bartlett from Saglek Bay, Labrador, September 1, 1925. The larger, 42 mm in length, had four rostral teeth, two on the carapace and two on the rostrum proper; the rostrum reached to the middle of the cornea and fell a little short of the first segment of the antennular peduncle. The smaller specimen, about 34 mm in length, was very typical of the species; its rostral teeth were five in number, two on the carapace and three on the rostrum proper; the rostrum was about as long as the eye, but a little short of the first segment of the antennular peduncle.

The Biological Board of Canada had a specimen of this species from a cod stomach from Port Burwell, Ungava, and two others determined as *S. zebra* Leim from the same source. Stephensen,[3] with Miss Rathbun,[4] believes that these two species are probably identical. In his paper Stephensen lists five localities on the southwest coast of Greenland where undoubted *S. microceros* has been obtained. Leim[5] records *S. zebra* from three localities in New Bruns-

[3] STEPHENSON, K. *Crustacea Decapoda, Godthaab Expedition.* Meddel. Grønland, **80** (No. 1): 81. 1935.

[4] RATHBUN, M. J. *Decapoda.* Canadian Atlantic Fauna, **10** m: 12. 1929.

[5] LEIM, A. H. *A new species of Spirontocaris with notes on other species from the Atlantic Coast.* Trans. Royal Canadian Instit. XIII (No. 4): 137. 1921.

wick and one in Nova Scotia, but makes no mention of *S. microceros*. Miss Rathbun contributes another locality for *S. microceros*: Misaine Bank, off Cape Breton Island, 45° 19′ N., 58° 51′ 15″ W., 45 fathoms.

Spirontocaris phippsii (Krøyer) (= *Hippolyte turgida* Krøyer). A 2. B 5, 6, 13, 14, 15. C 20–31. D 32. In occasional specimens of *S. phippsii* the lower or smaller of the two supra-orbital spines may fail to develop.

This species has also been taken by the Biological Board of Canada at Nottingham Island in Hudson Strait; and at Wakeham Bay and Port Burwell, Ungava, at the latter place from cod stomachs.

Spirontocaris spina (Sowerby). A 2, 3. B 7, 10, 14, 15. C 17, 21, 23, 25, 26, 27, 29, 30, 31. D 32. E 42. Also found in stomach of cod, Angmagssalik, east Greenland, August 27, 1931.

The Biological Board of Canada has taken this species in Hudson Bay, just south of Mansel Island in 88 fathoms; in Hudson Strait at Sugluk Creek; and in Wakeham Bay and Port Burwell, Ungava; at the last named locality, however, only from cod stomachs.

Spirontocaris fabricii (Krøyer). A 2, 3. B 11, 14. C 22, 23, 24, 25. One large ovigerous female about 65 mm long out of a lot of five specimens from Parker Snow Bay (C 22) carries an adventitious supraorbital spine on the right orbital margin. This abnormality is of some interest, as the identity of the specimen is otherwise beyond question.

This species, like *Chionoecetes opilio*, mentioned below, is found in Arctic Alaska, the Bering Sea, and Siberia, as well as from Casco Bay, Maine, to west Greenland. Miss Rathbun[6] has already reported *S. fabricii* from Port Burwell, Ungava, and the east side of Hudson Bay, where the Biological Board of Canada secured a specimen in 1930 north of Churchill in 30 fathoms; additional specimens were obtained from Wakeham Bay and from cod stomachs from Port Burwell, Ungava.

Spirontocaris gaimardii (Milne Edwards). A 1, 2, 3. B 4, 6, 8, 10–15. C 16, 22, 25–28, 31. D 32, 34. E 39, 40, 42. Also found in cod stomachs at Angmagssalik, east Greenland, August 27, 1931.

The Biological Board of Canada has taken *S. gaimardii* at two stations along the southwestern shore of Hudson Bay in from 20 to 38 fathoms; and again from cod stomachs at Port Burwell, Ungava.

Spirontocaris gaimardii belcheri (Bell). A 2. B 7, 10, 13. C 20, 23, 25, 27, 29. D 32. Also found in cod stomachs at Angmagssalik, east Greenland, August 27, 1931.

Von Hofsten (*op. cit.*, p. 29) does not believe that the subspecies of *S. gaimardii* can be sustained as distinct entities, and gives his distribution records as for the species proper.

Spirontocaris stoneyi Rathbun. E 39. The single specimen that Captain Bartlett dredged north of Big Diomede Island, Bering Strait, constitutes the third known record for the species. Originally described from the Bering Sea,[7] it has since been found at Shoal Tickle, southeast of Nain, Labrador.

Crago dalli (Rathbun). E 39.

Sabinae septemcarinata (Sabine). A 3. A single specimen was obtained from the stomach of a Ringed Seal secured off the Labrador coast in 1925. I cannot explain its absence from the dredge hauls made by Captain Bart-

[6] Rathbun, M. J. *Decapod Crustaceans.* Canadian Arctic Expedition, **7** (Pt. A): 13A. 1919.

[7] Rathbun, M. J. *Decapod Crustaceans.* Harriman Alaska Expedition, X: 103. 1904.

lett, for it was taken by the second Parry Expedition off Igloolik Island near the Straits of Fury and Hecla and occurs on both coasts of Greenland. It is a more or less circumpolar species.

In Hudson Bay it was taken by the Biological Board of Canada at nine stations in the southeastern central part of the Bay in depths ranging from 30 to 87 fathoms.

Sclerocrangon boreas (Phipps). B 6, 8, 10, 13. C 16, 18, 20, 22, 23, 25, 26, 27, 29, 30, 31. D 32, 33, 35, 37. E 39, 42.

Captain Bartlett found **Sclerocrangon boreas** in cod stomachs as well as in his dredgings from Angmagssalik, east Greenland, August 27, 1931.

This shrimp grows to good size and is one of the principal articles of food of the square-flipper seal, **Phoca barbata.** One to several dozen could be recognized from among the stomach contents of four different specimens of this seal. The two largest Sclerocrangons taken from these seal stomachs were $4\frac{1}{2}$ and 5 inches long. One of these square-flipper seals was captured in the Straits of Fury and Hecla, another in Lyon Inlet, and two out in Fox Basin at approximately 66° 12′ N., 78° 59′ W. The depth of the water in this vicinity is 34 fathoms.

Sclerocrangon boreas, says von Hofsten (*op. cit.*, p. 80), is a panarctic form, also penetrating the boreal region in favorable localities. It prefers very cold waters and ground overgrown with algae. The matted, fibrous contents of the stomachs of two seals from Fox Basin, which contained numerous *S. boreas* substantiates this.

In Hudson Bay the Biological Board of Canada obtained this crustacean at four stations more or less in the same latitude across the middle of the Bay at depths ranging from 30 to 72 fathoms; specimens were also collected at Nottingham Island, Hudson Strait; and at Port Burwell, Ungava from a cod stomach.

Sclerocrangon ferox (Sars). D 33. A truly high arctic form, found only in waters of very low, usually negative, temperature and at depths of ninety fathoms or more. We find but a single specimen in Captain Bartlett's collection, from 120 fathoms, near Cape Stosch, Hudson Land, east Greenland, 74° 04′ N., 17° 50′ W., July 30, 1931. This is the third specimen of the species ever to come to the National Museum and the first we have had from the western hemisphere.

Argis lar (Owen). E 39, 40, 41, 42. With this species Stephensen unites the next, *A. dentata* Rathbun. Though known from Greenland to Nova Scotia, and from the Bering Sea to British Columbia and east to Siberia, in Captain Bartlett's collection it is represented in hauls made only between Bering Strait and Kotzebue Sound in 1924.

Argis dentata (Rathbun). A 2. C 20, 22, 29, 31. D 32. Also found in cod stomach from Angmagssalik, east Greenland, August 27, 1931.

The Biological Board of Canada has specimens of this species from eight stations well scattered throughout Hudson Bay, with depths ranging from 30 to 80 fathoms; and both free swimming and from cod stomachs from Port Burwell, Ungava.

Pagurus krøyeri Stimpson. B 15. A single specimen taken off Igloolik Island at the entrance to the Straits of Fury and Hecla.

As European workers still merge this species with *P. pubescens* Krøyer, it is impossible to define the distribution of either species. In the National Museum there is an extensive series of *P. krøyeri* from along the east coast of America as far south as Virginia, 37° 19′ 45″ N., 74° 26′ 06″ W., from 120 fathoms; several Labrador localities are represented: off Narak, Nain, Port

Manvers, Cape Mugford, and Hebron, 7–60 fathoms; and Greenland: Godhavn Harbor, Disko Island, and Hare Island, 70° 20′ N., 56° W., 90 fathoms. Further, there are specimens from the Firth of Clyde, 10–15 fathoms, and from Varanger Fiord, East Finmark. For the specimens of true *P. pubescens* in the collection of the Museum, the southern limit is off Cape Hatteras, 35° 42′ 00″ N., 74° 54′ 30″ W., 43 fathoms, while the northern limit is Egg Harbor, Labrador, 7 fathoms.

The Biological Board of Canada got a specimen from each of two Hudson Bay stations on the west side of the Bay north of Churchill, in depths of 30 and 63 fathoms; and another specimen from a cod capture at Port Burwell, Ungava.

Pagurus trigonocheirus Stimpson. E 39, 40, 41, 42.

Pagurus capillatus (Benedict). E 42.

Pagurus splendescens Owen. E 39, 40, 41, 42.

Pinnixa occidentalis Rathbun. E 38. A single specimen from about the northern limit for this species, from the stomach of a fish caught 1½ miles S.E. of Cape Cheerful, Unalaska.

Chionoecetes opilio (O. Fabricius). E 40, 41. In its distribution, *C. opilio* is like *Spirontocaris fabricii*, occurring in the Pacific boreal and arctic regions, as well as on the northeast coast of America and west Greenland, but not in east Greenland. Unlike *S. fabricii*, its presence in Fox Basin cannot be established. Captain Bartlett's three specimens of this species are from the arctic coast of Alaska.

Hyas araneus (Linn.). A 3.

Hyas coarctatus alutaceus Brandt. A 3. C. E 39, 40, 41, 42. Captain Bartlett got one specimen of this species along the Labrador coast in 1925; fragments of 10 small individuals from a cod caught at Laxebugt, Disko Island, Greenland, in 1935; and 10 at four localities in the Bering Sea and Alaska in 1924.

The Biological Board of Canada obtained this crab in James Bay; at Fort Churchill and Churchill River; and at six dredge stations in the eastern and northwestern parts of Hudson Bay from depths of 19 to 82 fathoms; in Hudson Strait from Charles Island, Nottingham Island, Sugluk Creek, and Eric Cove; and at Cape Wolstenholme, Wakeham Bay, and Port Burwell, Ungava.

CRUSTACEA IDENTIFIED FROM THE STOMACH CONTENTS OF WHALES, SEALS, AND FISH

Sperm whale. Decapoda: *Chionoecetes opilio* (O. Fabricius).

Finback whale. Euphausiacea: *Thysanoessa inermis* (Krøyer), *T. raschii* (M. Sars).

Sulphur-bottom whale. Euphausiacea: *Thysanoessa raschii* (M. Sars). Amphipoda: *Themisto compressa* forma *bispinosa* Boeck.

Ringed or Floe-rat seal. Decapoda: *Sabinea septemcarinata* (Sabine). Euphausiacea: *Thysanoessa inermis* (Krøyer), *T. raschii* (M. Sars). Mysidacea: *Mysis oculata* (O. Fabricius). Amphipoda: *Themisto libellula* (Mandt), *Gammarus locusta* (L.).

Bearded or Square-flipper seal. Decapoda: *Sclerocrangon boreas* (Phipps). Isopoda: *Arcturus baffini* (Sabine).

Harp seal. Euphausiacea: *Thysanoessa inermis* (Krøyer). Amphipoda: *Themisto libellula* (Mandt).

Unidentified seal. Decapoda: *Spirontocaris gaimardii belcheri* (Bell). Mysidacea: *Mysis oculata* (O. Fabricius).

Codfish. Decapoda: *Pandalus borealis* Krøyer, *Spirontocaris groenlandica* (J. C. Fabricius), *S. polaris* (Sabine), *S. spina* (Sowerby), *S. gaimardii* (Milne Edwards), *S. gaimardii belcheri* (Bell), *Sclerocrangon boreas* (Phipps), *Argis dentata* (Rathbun), *Hyas coarctatus alutaceus* Brandt. Amphipoda: *Themisto libellula* (Mandt), *Anonyx nugax* (Phipps), *Pseudolibrotes nanseni* Sars, *Gammarus locusta* (L.), *Gammaracanthus loricatus* (Sabine).

Unidentified fish. Decapoda: *Pinnixa occidentalis* Rathbun.

ZOOLOGY.—*The histology of nemic esophagi. VI. The esophagus of members of the Chromadorida.*[1] B. G. CHITWOOD, Bureau of Animal Industry, and M. B. CHITWOOD.

This paper is the sixth of a series (Chitwood and Chitwood, 1934–1936) dealing with the structure of esophagi in representatives of various groups of nematodes. Previous papers in the series have covered representatives of the Rhabdiasidae, Strongylidae, Metastrongylidae, Heterakidae, Rhabditidae and Anguillulinidae. The present paper covers representatives of the order Chromadorida, namely: Plectidae, Camacolaimidae, Axonolaimidae, Comesomatidae, Cyatholaimidae, Tripyloididae, Desmodoridae, Chromadoridae, Monhysteridae, Linhomoeidae, and Siphonolaimidae. In representatives of the Chromadorida as in the other aphasmidian order, Enoplida, absolute identifications of nerve cell, radial and marginal nuclei are often not possible, as there is too little distinction between the characters of these 3 types of nuclei, and the cell bodies of "nerve cells" are seldom observable. However, the distribution of nuclei is sufficiently similar in the various genera for homologies to be ascertained. In the following text, the authors have identified nuclear types to the best of their abilities. In some instances it has been possible to determine cytologically the identity of a given nucleus, while in other cases the position indicated that the nucleus in question was homologous to one definitely identified in another form although they might differ cytologically in some respects. Future papers will include representatives of the orders Enoplida (Enoplata, Dorylaimata, and Dioctophymata) and Spirurida (Camallanata and Spirurata).

The data given in this paper are, for the most part, presented in tabular form (Figs. 3, 5, 10) and in illustrations, since the essay form of presentation would result in extended descriptions requiring much more space than the present form. The text calls attention to the major features given in the tables and illustrations, and presents some data not immediately obvious in the latter. Previous papers in

[1] Received June 22, 1936.

this series supply extended descriptions of other forms, sufficient to orient the reader of the present paper.

PLECTUS GRANULOSUS (Plectidae) Figs. 1, 2, 3

The esophagus of *Plectus* resembles in a general way that of *Rhabditis*, as does the mouth cavity; it consists of an anterior cylindrical part, the corpus, connected with a posterior swelling or bulb by an indistinctly set off isthmus. The lumen of the esophagus is similar to that of *Rhabditis* in that in the precorpus it terminates marginally in well developed "tubes" (Fig. 1, B), while in the remainder of the esophagus the lumen is simple, i.e., without particular modification, except in the bulb where it is hexalobate at the valve.

The precorpus contains 29 nuclei (Fig. 1, A-E) as follows: One group of 3 bilobed or 6 marginal nuclei, (m_{1a-b}–m_{3a-b}); 3 groups of 6 radial nuclei each (r_{1-6}, r_{7-12}, and r_{13-18}); and 2 groups of nerve cell nuclei (n_{1-3} and n_{5-6}). The marginal nuclear pairs, m_{1a-b} etc., may or may not be connected in such a way as to represent lobes of a single nucleus rather than individual nuclei; however, it is not possible to determine this on the basis of present material. A similar appearance is given by the marginal nuclei in *Rhabditis*, in which case the lobes were found to be joined anteriorly (Chitwood and Chitwood, 1936).

The postcorpus contains 26 nuclei (Fig. 1, F-L); 6 marginal nuclei (m_{4a-b}–m_{6a-b}), similar to those of the margins of the precorpus, 6 radial nuclei (r_{19-24}), and 14 nerve cell nuclei ($n_{4,7-19}$). The isthmus is too indistinct to be recognized as a unit. The most posterior nerve cell nuclei of the postcorpus might be considered as belonging to the isthmus.

The prevalvar region of the bulb contains 14 nuclei (Fig. 1, O–P), of which 6 are marginal nuclei (m_{7a-b}–m_{9a-b}), 6 radial nuclei (r_{25-30}), and 2 nerve cell nuclei (n_{20-21}).

The postvalvar region of the bulb contains 24 nuclei as follows (Fig. 1, Q–S); 6 marginal nuclei or nuclear lobes (m_{10a-b}–m_{12a-b}), 6 radial nuclei in 2 groups (r_{13-33}, r_{34-36}), 9 nerve cell nuclei (n_{22-30}), and 3 gland cell nuclei (g_{1-3}). The marginal nuclear pairs of the postvalvar region of the bulb appear in all probability to represent lobes rather than individual nuclei. In the series illustrated (Fig. 3) m_{11} is not double; n_{23-24} were not observed.

The orifices of the esophageal glands were not determined with absolute certainty. The dorsal gland appears to open into the lumen at the base of the stoma, while the subventrals appear to open at or near the level of n_{17-19}.

The esophago-intestinal valve of *Plectus* is extremely well developed (Fig. 2, A–C) and consists of 23 nuclei. (Some of these nuclei are probably intestinal—compare Figs. 2, B–C and 2, I). The valve is laterally elongated and rather flat.

Two other representatives of the same subfamily, very closely related to *Plectus*, were studied, these being *Chronogaster gracilis* and *Wilsonema bacil-*

livorus, in both of which the nuclei of the esophagus appear to be similar in number and distribution to those of *Plectus.*

Anonchus mirabilis (Plectidae) Figs. 2, D–F; 3

The esophagus of *Anonchus mirabilis* is cylindrical in the adult stage, but corpus, isthmus and pseudobulb are faintly recognizable in larval stages.

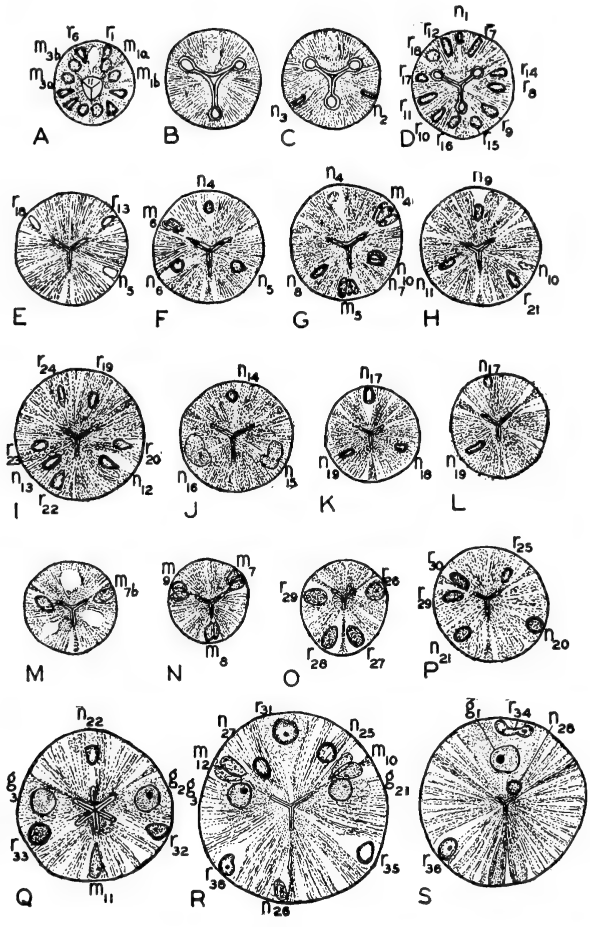

Fig. 1.—*Plectus granulosus.* A–F, precorpus; F–L, postcorpus; M–P, prevalvar region; Q–S, postvalvar region (See Fig. 2, B, for n_{29-30}).

The lumen is simple and triradiate, without marginal "tubes" (Fig. 2, E). The most striking pecularity of the esophagus is the presence of large chromidial bodies in the marginal regions (Fig. 2, D).

The nuclear number and distribution is nearly identical with that of *Plectus granulosus,* the following differences being noted: n_{20-21} and n_{23-24}

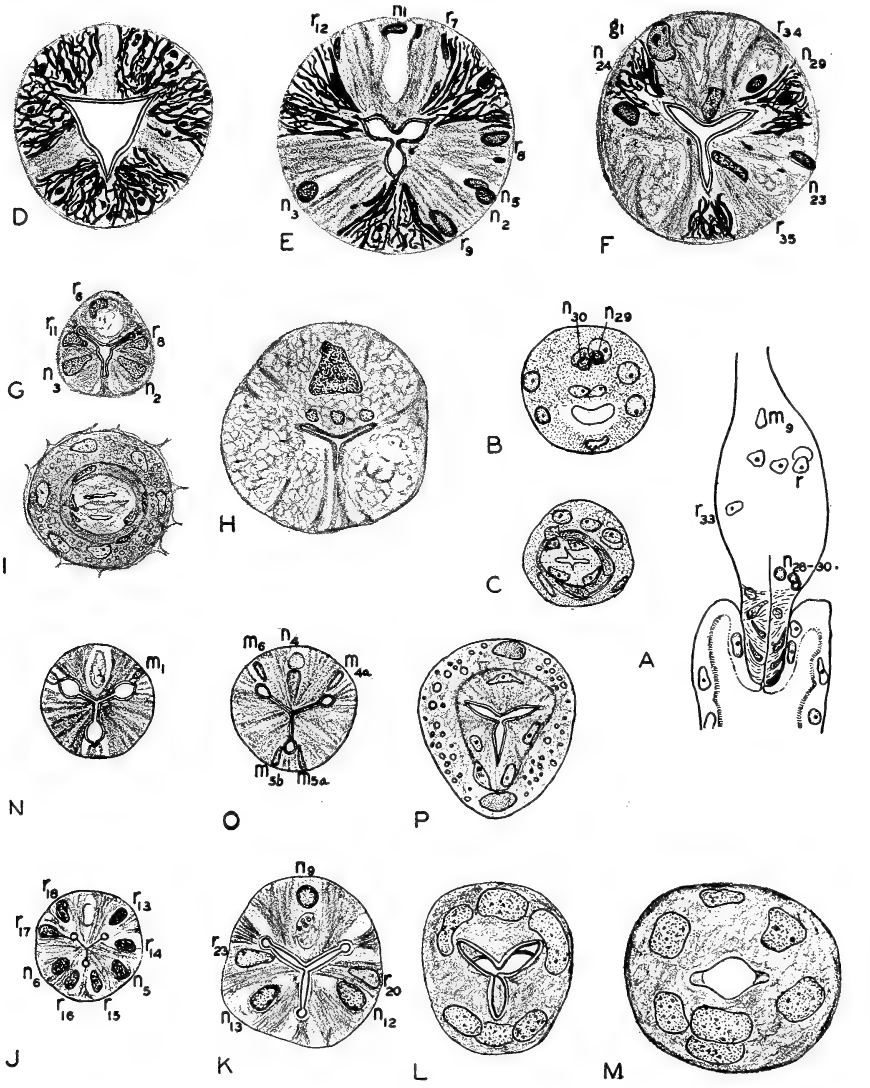

Fig. 2.—A–C, *Plectus granulosus*. A, Longitudinal section through bulb and esophago-intestinal valve; B–C, Cross sections, through esophago-intestinal valve (also includes very small part of bulb with n_{29-30}). D–F, *Anonchus mirabilis*. D, corpus at base of stoma; E, corpus somewhat further posterior; F, bulbar region. G–I, *Camacolaimus prytherchi*. G, corpus; H, base of bulbar region showing g, and n_{28-30}; I, esophago-intestinal valve. J, *Axonolaimus spinosus*, corpus. K–M, *Sabatieria vulgaris* K, corpus; L-M, esophago-intestinal valve. N–P, *Paracanthonchus* sp. N, anterior part of corpus O, corpus somewhat more posterior, P. esophago-intestinal valve.

are in the dorsal parts of their respective sectors; n_{25} and n_{26} have not always been found; n_{27} has not been observed; the marginals have been inconsistently observed owing to the confusion caused by the marginal chromidial bodies.

The marginal nuclei are very faint and nothing definite can be said about them. The gland cell nuclei differ from the other nuclei in that several small nucleoli are present instead of a single large one (see Fig. 2, F). The esophageal glands are very large and there is a vesicle near the orifice of each gland. The dorsal gland opens into the lumen of the esophagus anterior to the level of the first radial group, while the subventrals open anterior to the level of n_{17-19}.

The esophago-intestinal valve is similar to that of *Plectus* but the dorso-ventral form is more pronounced. Eleven large nuclei and possibly 4 smaller ones were observed in this structure.

CAMACOLAIMUS PRYTHERCHI (Camacolaimidae) Figs. 2, 3

The esophagus of this species is cylindroid, slightly constricted at the nerve ring, and gradually enlarged posteriorly. The lumen is normally closed, simple or triradiate, and minute marginal "tubes" are present only in the anterior part of the esophagus (Fig. 2, G). There is a total of 81 nuclei, the same number as in *Plectus* if the marginals are considered as lobed nuclei rather than double nuclei. The following differences in nuclear distribution in this species, as compared with *Plectus granulosus*, have been noted: N_{23} and n_{24} are in the ventral or marginal regions of their respective sectors; n_{26} is anterior to m_{11}; the fifth group of radials is subdivisible into 2 groups, $r_{25,\ 27,\ \text{and}\ 28}$ being posterior to $r_{30,\ 26,\ \text{and}\ 29}$ respectively; $r_{14\ \text{and}\ 22}$ were not always observed.

The esophageal glands are much more highly developed in *Camacolaimus* than in *Plectus* and occupy the greater part of the bulbar region (Fig. 2, H). The dorsal esophageal gland appears to open into the lumen slightly anterior to m_{1-3}, while the subventrals open near the level of n_{15-16}.

The esophago-intestinal valve (Fig. 2, I) is elongated, dorso-ventrally flattened, and contains 11 nuclei (only 8 shown in figure).

The rudimentary stoma is surrounded by esophageal tissue and contains a dorsal tooth which is apparently not connected with the dorsal esophageal gland.

APHANOLAIMUS sp. (Camacolaimidae) Fig. 3

The esophagus of *Aphanolaimus* is narrow, gradually enlarged posteriorly and without visible modified regions; the stoma is completely rudimentary and esophageal tissue extends to the anterior extremity. The esophageal lumen is simple, as is also the esophageal lining.

The first, second and fourth groups of marginal nuclei are simple, while the third group is lobed as in *Plectus*. There are a total of 80 nuclei, corresponding to those of *Plectus* with the following exceptions, m_{7bx} and m_{9ax} were inconsistently observed as lobes of m_{7b} and m_{9a}, respectively; n_{27} is posterior to g_1; $r_{25\ \text{and}\ 28}$ are nearly marginal in position; n_{23-24} were not observed but 1 nucleus, x_1, marginal in position, and in the right subventral sector, may correspond to n_{24}.

The esophago-intestinal valve is similar to that of *Camacolaimus*.

The esophageal glands are similar to those of *Camacolaimus* except that the dorsal gland nucleus is near the left side of the dorsal sector.

AXONOLAIMUS SPINOSUS (Axonolaimidae) Figs. 2, J; 3

The esophagus of *Axonolaimus* is clavate, relatively short, and muscular throughout. This form is very close to *Plectus* in the character of the stoma and also in the presence of well developed marginal "tubes" in the corpus (Fig. 2, J). The nuclear distribution of the corpus is closer to that of *Plectus* than to any of the forms previously mentioned. The first marginal group appears to consist of 6 separate and distinct nuclei (m_{1a-1b}–m_{3a-3b}); this is followed by the first 3 radial groups ($r_{1-6,7-12,13-18}$) in series. The second marginal group appears to be somewhat variable. In the series illustrated it consists of 7 separate nuclei, 4 ($m_{4a1,4a2}$ and $m_{6a1,6a2}$) being present in the dorsal sector, 2 (m_{4b} and m_{5a}) in the left subventral sector, and 1 (m_{5b}) in the right subventral sector. The fourth group of radial nuclei appears to consist of 6 or 8 nuclei (r_{19-24}) with the ventral nucleus in each subventral sector sometimes doubled ($r_{21a,21b}$ and $r_{22a,22b}$). The nerve cells of the corpus agree in number and position with those of *Plectus*.

The nuclei of the bulbar region are difficult to identify, and the labelling given in Fig. 3 is to some extent arbitrary. The nuclei labelled c_{1-3} are large and bilobed; $n_{23 \text{ and } 24}$ also appear to be bilobed in some instances.

The dorsal esophageal gland orifice is situated just anterior to the first group of marginal nuclei, while the orifices of the subventral glands appear to be near the level of n_{18-19}.

The esophago-intestinal valve is well developed but not so elongated as in *Plectus*; it is distinctly triradiate anteriorly and rather circular posteriorly, containing 10 to 11 nuclei. It is very similar to the valve of *Subatieria vulgaris*.

For purposes of comparison with *Plectus*, the total number of nuclei or nuclear lobes in the corpus is 58 (55 in *Plectus*) and in the bulbar region 35, 38 or 40 (38 in *Plectus*).

DORYLAIMOPSIS METATYPICUS (Comesomatidae) Fig. 5

The stoma and esophagus of *Dorylaimopsis* are closest, among the forms thus far studied, to those of *Axonolaimus*. The marginal "tubes" are well developed, and there is a very slight thickening of the cuticular lining extending throughout the corpus. The first and second marginal groups appear to consist of 3 bilobed nuclei. Data regarding the radial nuclei are not entirely satisfactory, but there appear to be 22 or 24 radial nuclei (in 4 groups) in the corpus, r_7 and r_{12} of *Axonolaimus* being the ones sometimes absent. The nerve cell nuclei (n_{1-19}) of the corpus agree with those of *Axonolaimus*. The marginal nuclei of the bulbar region (m_{7-9} and m_{10-12}) are simple. As in *Axonolaimus*, r_{27} and r_{28} are posterior to r_{26} and r_{29}, but r_{25} and r_{30} are at the

level of r_{27} and r_{28}. The last group of radials presents the unusual arrangement of r_{32} and r_{35}, being anterior to the level of r_{33} and r_{34} which are in turn anterior to r_{31} and r_{36}; the closest counterpart of this grouping is seen in *Theristus*. The nerve cells of the bulbar region correspond in number to those of *Plectus*, n_{20-21} being just posterior to r_{27-28} and slightly ventral to the mid-

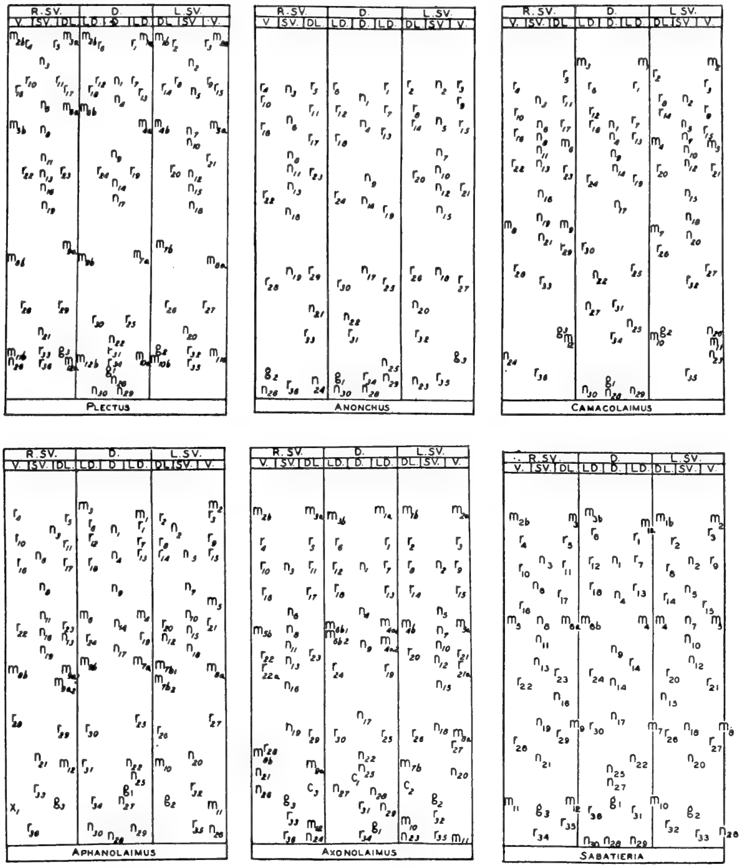

Fig. 3.—Table of nuclear distribution.

sector region; n_{23-24} are subventral, posterior to r_{33-34}; $n_{22,25,30}$ are distributed approximately as in *Plectus;* g_{1-3} are all in the center of their sectors between the levels of r_{33-34} and r_{31} and r_{36}. The esophageal glands of *Dorylaimopsis* are highly developed; the dorsal gland orifice is at the base of the stoma, and the subventral gland orifices are at the level of n_{18-19}. The glandular tissue is relatively much greater in this form than in *Axonolaimus* or *Plectus* but not as great as *Camacolaimus*. The esophago-intestinal valve is small and dorsoventrally flattened, and contains 12 nuclei.

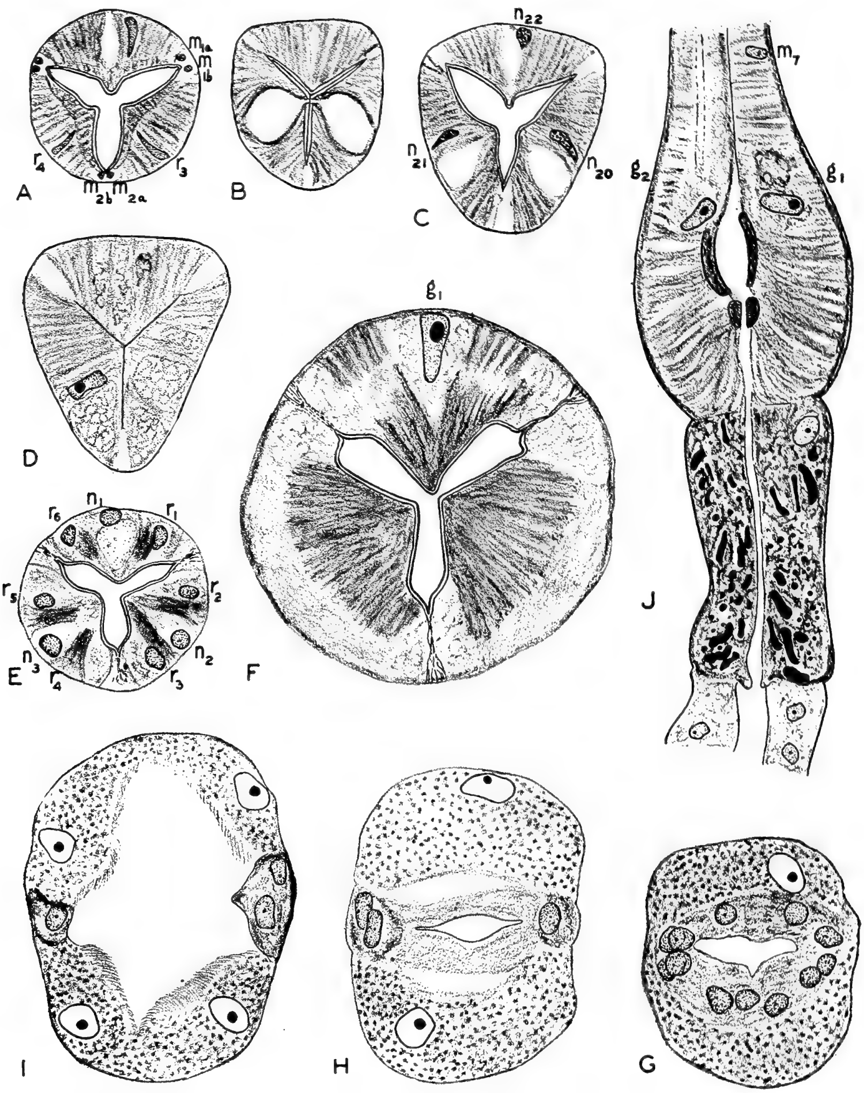

Fig. 4.—A–D, *Theristus setosus.* E–I, *Terschellingia pontica.* E, corpus; F, bulbar region; G–I, serial sections through esophago-intestinal valve. J, *Desmolaimus zeelandicus* v. *americanus*, longitudinal section through bulb, and esophago-intestinal valve.

SABATIERIA VULGARIS (Comasomatidae) Figs. 2, K–M; 3

The esophagus of *Sabatieria* is like the esophagi of *Axonolaimus* and *Dorylaimopsis* in that well developed marginal "tubes" are present. In the gross morphology, shortness and relatively great development of the esophageal glands is more nearly like *Dorylaimopsis* than *Axonolaimus.* Un-

like both of the mentioned forms, the posterior part of the stoma is collapsed and completely surrounded by well developed esophageal tissue.

The nuclei of the esophagus agree substantially with *Dorylaimopsis* both in number and distribution (See Figs. 3, 5). The lumen of the esophago-intestinal valve is triradiate anteriorly, laterally elongated posteriorly; 12 nuclei are present in the valve.

The dorsal esophageal gland has its orifice near the level of m_{1-3}, i.e., posterior to the base of the collapsed stoma. The subventral glands have their orifices at the level of n_{17}, i.e., the level of the nerve ring.

PARACANTHONCHUS sp. (Cyatholaimidae) Fig. 2, N–P

The esophagus of *Cyatholaimus* presents several interesting modifications. The stoma is completely surrounded by esophageal tissue, and a dorsal tooth projects into the anterior part of the lumen. This tooth probably corresponds to one of the three present in *Dorylaimopsis*. There is no evidence of its connection with the dorsal esophageal gland which appears to have its orifice at the base of the stomatal region. The slightly clavate esophagus presents no external peculiarities except that the lumen (Fig. 2, N) is rather unusual, the general appearance being that of an axonolaimoid or plectoid form (Figs. 1, 2, J) in which the termini of the margins have become converging after having once been tubular; this is best visualized by comparison of the illustrations.

Both the marginal and radial nuclei are practically marginal in position; the marginal nuclei of the corpus are double. Since our series are incomplete, no attempt to give nuclear distribution will be made. However, the general impression is very similar to that given by *Dorylaimopsis*.

The esophago-intestinal valve is short, markedly triradiate (Fig. 2, P) and consists of 8 nuclei which definitely belong to the valve, and 5 additional nuclei which also may belong to that structure; there are also 4 nuclei dorsal to the esophagus in a mass which apparently connects with the body wall.

BATHYLAIMUS sp. (Tripyloididae)

The esophagus of *Bathylaimus* is cylindrical, and surrounds the conoid stoma. The lumen is nearly of a simple triradiate character; the esophageal radii extend nearly to the external surfaces in *Theristus* but the margins are very faintly rounded showing a similarity to *Sabatieria*. The general outline of the esophageal cross-section is subtriangular, not unlike that of *Theristus* (Fig. 4, A) instead of nearly round as in the forms previously described. The position and form of the radial and marginal nuclei are also more like that of *Theristus* than of *Cyatholaimus*. The radial muscles are diffuse in attachment to the lining. Incompleteness of our series prevents us from giving further data on the structure of this form. The esophago-intestinal valve is triradiate.

THERISTUS SETOSUS (Monhysteridae) Figs. 4, A–D; 5

The esophagus of *Theristus* is cylindrical, its lumen simple, and the lining unmodified. The dorsal esophageal gland opens near the base of the conoid stoma, while the subventral esophageal glands open near the level of n_{15-16}. The radial and marginal nuclei differ greatly in size as well as in position (Fig. 4, A). When clearly observed, the first 2 groups of marginal nuclei are

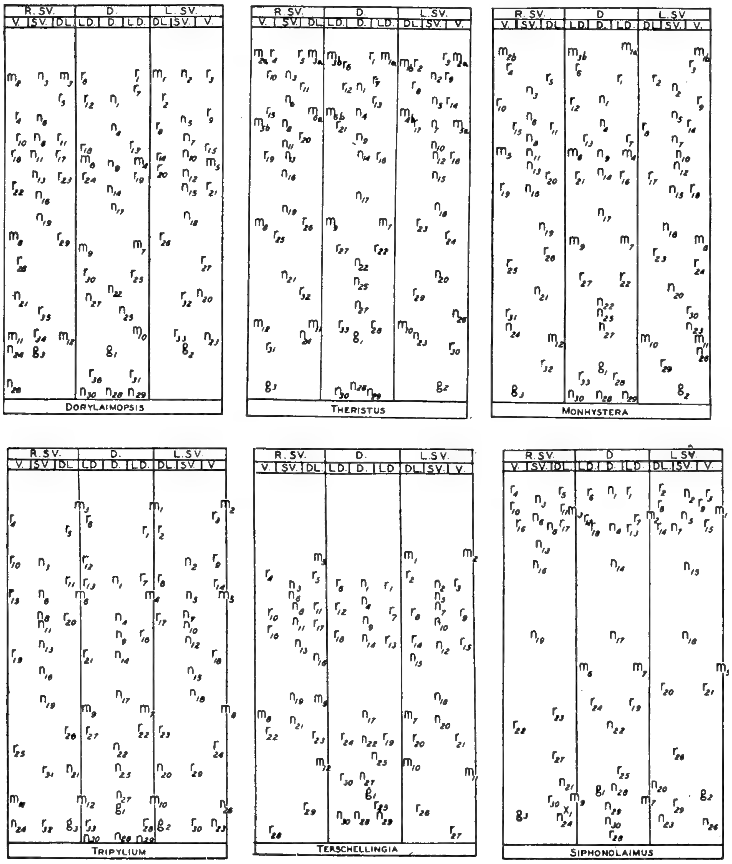

Fig. 5.—Table of nuclear distribution.

double, while the fourth is not doubled. The third group of radial nuclei consists of only 3 instead of 6 present in other forms. The esophago-intestinal valve is partially triradiate (anteriorly), but at the junction with the intestine it is definitely flattened dorsoventrally, practically identical with *Terschellingia* (Fig. 4, H); it contains 23 nuclei.

MONHYSTERA CAMBARI (Monhysteridae) Fig. 5

The esophagus of *Monhystera cambari* is similar to that of *Theristus,* with the following exceptions. The representatives of the fourth group of radial nuclei (r_{16-21}) are all at the same level or nearly so; n_{23-24} are ventrally sub-

marginal just posterior to the level of r_{30-31}; r_{29-32} and r_{30-31} are at levels in reverse of the levels at which they are, respectively, in *Theristus*; all of the marginals are simple except m_2 (not doubled). The esophago-intestinal valve is similar to that of *Theristus* and *Terschellingia*; 19 nuclei were observed.

TRIPYLIUM CARCINICOLUM V. CALKINSI (Linhomoeidae) Figs. 5, 6

The esophagus of *Tripylium* is cylindroid; anteriorly it surrounds the prismoidal stoma; posteriorly it is connected with the intestine through an enlargement commonly termed the "bulb" though this structure is not a

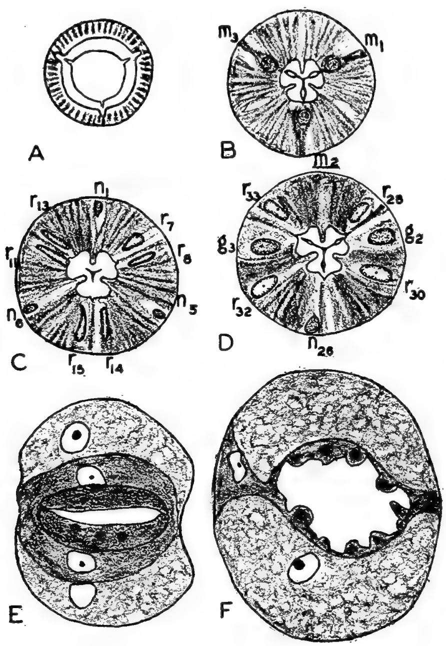

Fig. 6.—*Tripylium carcinicolum* v. *calkinsi*. A, stomatal region; B–C, corpus; D, bulbar region; E–F, esophago-intestinal valve.

part of the esophagus. The lumen is modified throughout due to the thickened cuticular attachment points of the lining (Fig. 6, C). This type of lumen appears to be derived from a plectoid or rhabditoid type in which there has been a disappearance of the marginal tubes and a development of attachment points for the radial muscles; such a phenomenon occurs in the development of forms such as *Oesophagostomum*.

The nuclei are distributed as in *Theristus*, with the following exceptions. The marginal nuclei are not doubled and are directly marginal in position (Fig. 6, B); r_{22} and r_{27} are at the same level as r_{23} and r_{26}; r_{28} and r_{33} are posterior to r_{29} and r_{32}; n_{23-24} are ventral submarginal and immediately anterior to the level of n_{28-30}, n_{26} being just anterior to n_{23-24}.

The esophago-intestinal valve is dorsoventrally flattened (Fig. 6, E–F), but some explanation regarding this region is necessary. Baylis (1915) and

Cobb (1920) have considered the swelling as an esophageal "bulb," and actually this structure is formed by the esophago-intestinal valve and the intestine. At least 12 nuclei are ectodermal in origin; the external tissue forming the "bulbar" enlargement, probably endodermal in origin, contains 4 nuclei. The cytology of the latter is identical with that of the intestinal cells following it.

In the related linhomoeid, *Desmolaimus*, there is a cylindrical elongated structure (Fig. 4, J) between the esophagus and intestine; the definite ectodermal valve tissue makes up only a small part of the esophago-intestinal cylinder. However, in this case the tissue is peculiar in being basophilic and differing both from the esophagus and the intestine. The esophagus is similar in all respects to that of *Tripylium* except for a well developed chromodoroid swelling at its base. On the basis of comparison with the postesophageal structure of linhomoeids, this structure must be considered as a new organ.

TERSCHELLINGIA PONTICA (Linhomoeidae) Figs. 4, E–I; 5

The esophagus of *Terschillingia* consists of a cylindrical corpus, following a rudimentary stoma, and a well developed bulb; the latter is actually a part of the esophagus, not a homologue of the so-called bulb of *Tripylium* but a homologue of the bulb of *Desmolaimus*. The lumen is subdistally dilated (Fig. 4E, F); the musculature is concentrated, but no cuticular thickenings of the lining are present. The nuclear distribution (Fig. 5) is rather similar to that of *Tripylium*, *Theristus*, and *Monhystera*, but only three groups of radial nuclei were observed in the corpus; n_{23-24} and n_{26} were not observed. The dorsal gland orifice is slightly anterior to the level of the first group of marginal nuclei (m_{1-3}) while the subventral gland orifices are at the level of n_{15-16}. The esophago-intestinal valve (Fig. 4, G–I) is very strongly dorsoventrally compressed and contains at least 19 nuclei, probably more. It is surrounded by intestinal epithelium as in *Tripylium*.

SIPHONOLAIMUS CONICUS (Siphonolaimidae) Fig. 5

Siphonolaimus is a peculiar form concerning the stoma and esophagus of which there has been much discussion. Being limited to a study of a single series of sections, the writers present the results of their study of this form with as little interpretation as possible. The minute stoma seems to be in the form of a stomatostyle surrounded by muscular tissue which consists of 6 strands passing posteriad and closely applied posteriorly to the anterior end of the esophagus, then passing to the body wall where they are inserted sublaterally. The stomatostyle overlies the anterior end of the esophagus in which 3 distinct cavities are present. Whether or not these cavities represent the 3 esophageal glands is not known; only the dorsal cavity is traceable posteriorly past the isthmus.

In the corpus a total of 37 nuclei were observed, 16 corresponding to n_{1-16} of other forms, while the remainder are marginal and radial nuclei. The lat-

ter probably correspond to m_{1-3}, r_{1-6}, r_{7-12} and r_{19-24} other forms, i.e., the third radial group and second marginal group are apparently absent. The bulbar region contains 32 nuclei. The esophago-intestinal valve is dorsoventrally flattened and contains 6 nuclei which definitely belong to the valve.

MONOPOSTHIA HEXALATA (Desmodoridae) Figs. 7, 10

The esophagus of *Monoposthia* is, in general, typical of the Chromodoroidea and Desmodoroidea. The prismoidal stoma (Fig. 7, A) is surrounded by esophageal tissue which protrudes anteriorly into the lumen in

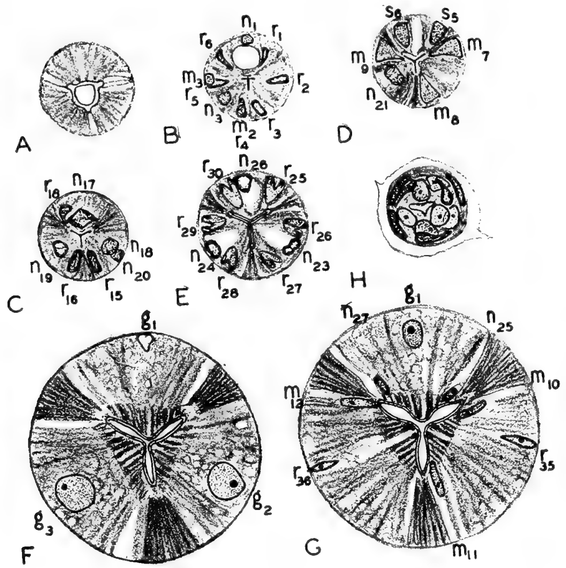

Fig. 7.—*Monoposthia hexalata.* A–C, corpus; A, in stomatal region; B, just posterior to orifice of dorsal gland; C, near base; D–G, bulbar region; H, esophago-intestinal valve.

the form of a large dorsal tooth. The post-stomatal region of the esophagus consists of a cylindroid corpus gradually enlarged posteriorly and joined directly to the short thick bulb. The lumen of the corpus is very minute, showing but faint indications of terminal "tubes."

The corpus contains 55 nuclei as follows: 2 groups of 3 marginal nuclei (m_{1-3} and m_{4-6}); 4 groups of 6 radial nuclei ($r_{1-6,\ 7-12,\ 18-24}$); 19 nuclei (n_{1-19}) presumably of nerve cells; and 4 nuclei (s_{1-4}) possibly of nerve cells.

The bulb contains 40 nuclei as follows: 2 groups of 3 marginal nuclei (m_{7-9}, m_{10-12}); 12 radial nuclei in 3 groups (r_{25-30}, r_{31-33}, r_{34-36}); 3 gland nuclei (g_{1-3}); 10 presumptive nerve cells (n_{22-30}); and 8 possible nerve cells (s_{5-12}); and 1 nucleus of uncertain type (x_1).

The dorsal esophageal gland appears to open into the lumen of the esophagus near the level of n_1, while the subventrals appear to open near the anterior end of the bulb (around the level of n_{20-21}).

The esophago-intestinal valve is short, more or less triradiate, and contains about 12–15 nuclei (Fig. 7, H).

Metachromadora, a closely related form of the same family, has an esophagus similar in a general way to that of Monoposthia but the esophageal lining has well developed thickenings for the attachment of radial muscles, particularly well developed in the bulbar region.

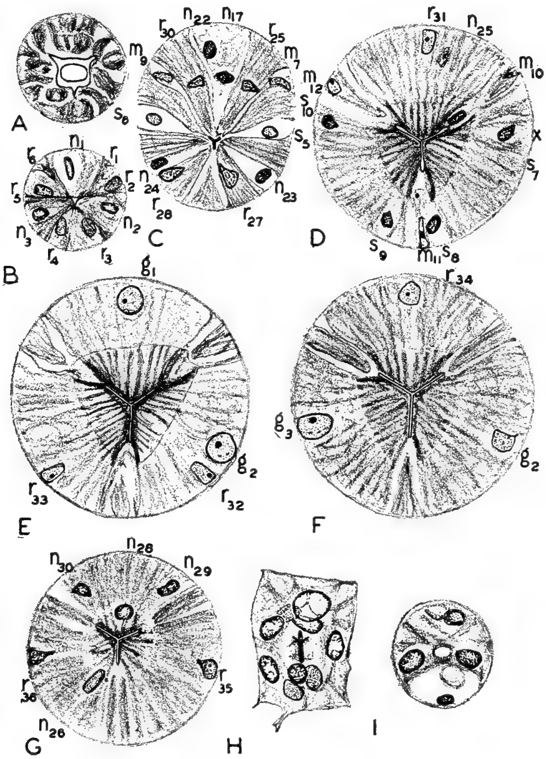

Fig. 8.—*Ethmolaimus rivaliensis.* A, stomatal region; B, corpus; C–G, bulbar region; H–I, esophago-intestinal valve.

ETHMOLAIMUS RIVALIENSIS (Chromadoridae) Figs. 8, 10

This form is nearly identical in esophageal structure with *Monoposthia*. The stoma, lumen and gross morphology are similar. The nuclei of the corpus (55) appear to be similar in character and distribution, there being 6 marginal nuclei, 24 radial nuclei, and 4 questionable (s_{1-4}). Most of the nuclei (total 39) of the bulb likewise correspond to those of *Monoposthia*, with the following exceptions, s_{5-6} were not recognized but 2 additional nuclei were sometimes observed in the left subdorsal sector.

The esophago-intestinal valve is short, dorsoventrally elongated, and contains 13 nuclei.

CHROMADORA sp. (Chromadoridae) Figs. 9, D–K; 10

The esophagus of this form is similar to that of *Ethmolaimus* and of *Monoposthia*, with the following exceptions: Grossly the stomatal region is not set off from the remainder of the esophagus and the bulbar region is relatively much shorter and smaller; the distinction between marginal and radial regions is more marked; 6 additional nuclei were observed in the corpus (x_{1-6}); the third group of radial nuclei is double (hence 6); s_5, s_6, n_{22a}

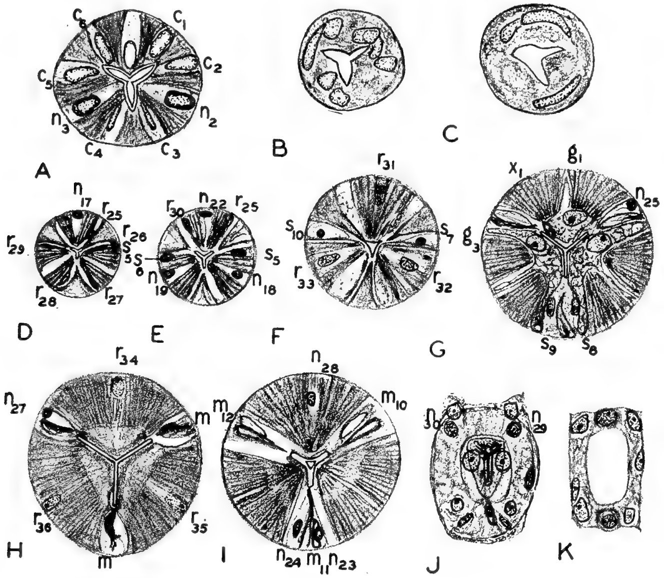

Fig. 9.—A–C, *Microlaimus* sp. A, corpus; B–C, esophago-intestinal valve. D–K, *Chromadora* sp. D–I, serial sections through bulbar region; J–K, esophago-intestinal valve.

(of *Monoposthia*) were not observed; additional nucleus (x_7) right laterodorsal was observed near the level of g_1, otherwise the nuclei in the bulbar region are as in *Monoposthia*. The esophago-intestinal valve is dorsoventrally elongated, consisting of 12 nuclei. *Chromadora* exhibits a pair of subdorsal pigment spots which consist of masses of brown granules in the subdorsal marginal and submarginal areas of the esophagus just posterior to the stomatal region; no special cells were observed in association with the spots.

MICROLAIMUS sp. (Microlaimidae) Figs. 9, A–C; 10

The esophagus of Microlaimus resembles that of Chromadora more closely than any other of the forms studied. The subtriangular stoma is surrounded by esophageal tissue, the corpus is cylindrical, the bulbar region quite enlarged and the esophago-intestinal valve elongated. The lumen (Fig. 9, A) is without marginal tubes and the lining without thickened cuticular attachment points though the radial fibers are highly concentrated. The number of nuclei and their disposition is clearly most like *Monoposthia*, *Ethmolaimus*

and *Chromadora* (compare Figs. 7–10). However, in addition to the nuclei s_{1-10}, there is a group of 6 nuclei (c_{1-6}) apparently resulting from further division of the second radial group (r_{7-12}). The elongate form of the esophago-intestinal valve grossly recalls the form of that structure in *Camacolaimus, Plectus,* or *Terschellingia,* but the cross section (Fig. 9, B–C) clearly indicates other relationships since it is plainly triradiate. It contains 11 nuclei.

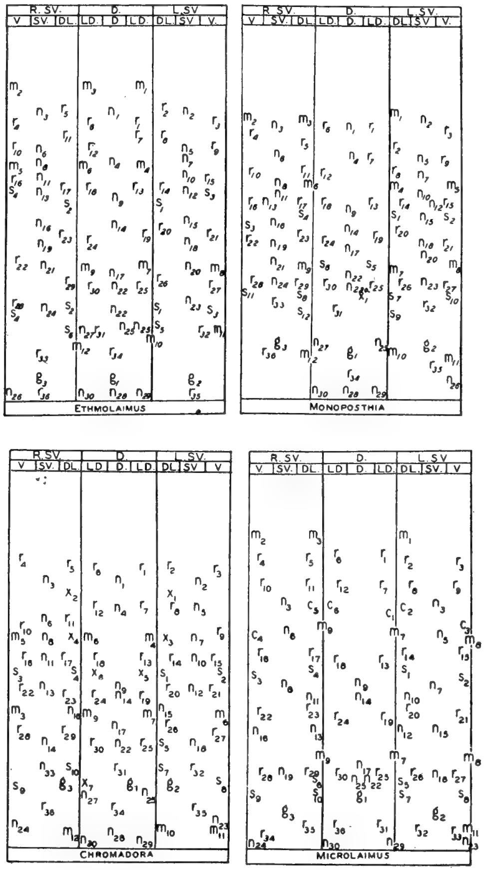

Fig. 10.—Table of nuclear distribution.

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JOURNAL
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OCEANOGRAPHY.—*Simple portable tide-gages.*[1] CHESTER K. WENTWORTH, Board of Water Supply, Honolulu, T. H. (Communicated by W. W. RUBEY.)

The tide-gages described below have been devised in connection with the study of bench-forming processes on the island of Oahu. They are described here in order to indicate the convenience and accuracy of simple apparatus of this sort for use by various naturalists who may have occasion to make moderately precise local measurements of sea level or tidal fluctuations. Their chief value is for those who require determinations within 0.1 or 0.2 foot and who wish to avoid the bias of off-hand estimating of sea-level which may result from use in estimating, of just those features whose level is to be determined. Even for such rather rough estimates, an instrumental method applied directly to the water level has superior validity, especially when used by various persons.

THE MANOMETER TYPE. This consists of a reservoir, such as a gallon syrup jug, to which are connected, (a) a syphon and 25 to 50 feet of $\frac{1}{4}$ inch rubber hose, (b) a mercurial manometer made up of glass tube with rubber hose bends bound to a section of meter stick, or prepared scale and, (c) a short vent tube. By applying suction to the jug, a water level may be maintained in it which is above the average of wave fluctuations in the sea to which the long tube reaches, by an amount indicated by the reading of the mercurial manometer. In actual use the jug is nearly filled with sea water and the sea tube tossed into the sea after starting the syphon. After the syphon has run long enough to fill the tube with water, the vent tube is closed and the syphon continues to run until rarification of air in the chamber has reached a balance with the water-level difference. This occurs within one or two minutes and the amount of water level difference can be computed from the mercury difference shown on the manometer, or a scale can readily be constructed so that the manometer reads directly in feet of sea water. The effect of three- or four-

[1] Received March 16, 1936.

foot waves in the sea on the water surface within the jug is negligible and the pulsation of the manometer is comparatively slight, owing to the damping effect of the long tube. The general form of the apparatus and its relations when in use are shown in Figs. 1 and 2.

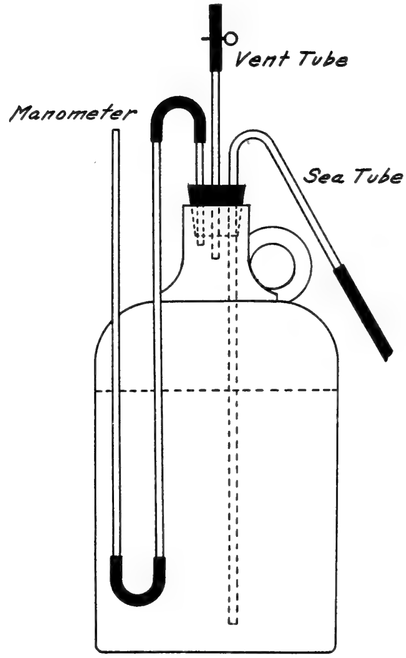

Fig. 1.—Manometer type of portable tide-gage. Glass parts in outline, rubber parts in black, supports and scale omitted.

Other types of tide-gage. Two other principles were applied in devising simple gages. In a dilatometer type, a small air chamber is closed off with air at atmospheric pressure above a column of sea water extending down the sea tube and rising to a point marked on a gage tube. Then a lower valve is opened and the water level drops to a new position of balance in the gage tube. The increase in volume of the air is a measure of decrease of pressure, by Boyle's law, and it is easy to compute, or to read on a calibrated scale, the indicated difference between final water level in the gage tube and the mean of sea level pulsations. A capillary or some other form of damping is necessary in this type to secure accurate readings.

An orifice type was also used, based on the principle that rate of flow through a given orifice is a function of head. The procedure is to measure the time required for a fixed amount of water, as from a sort of bulb-pipette, to flow through a small glass jet under the pull

due to pressure difference between the mean levels in the pipette and in the sea, as connected by the water column in the sea tube. This device achieves an automatic integration and measurement of mean differences through the half minute or more of flow, as built and

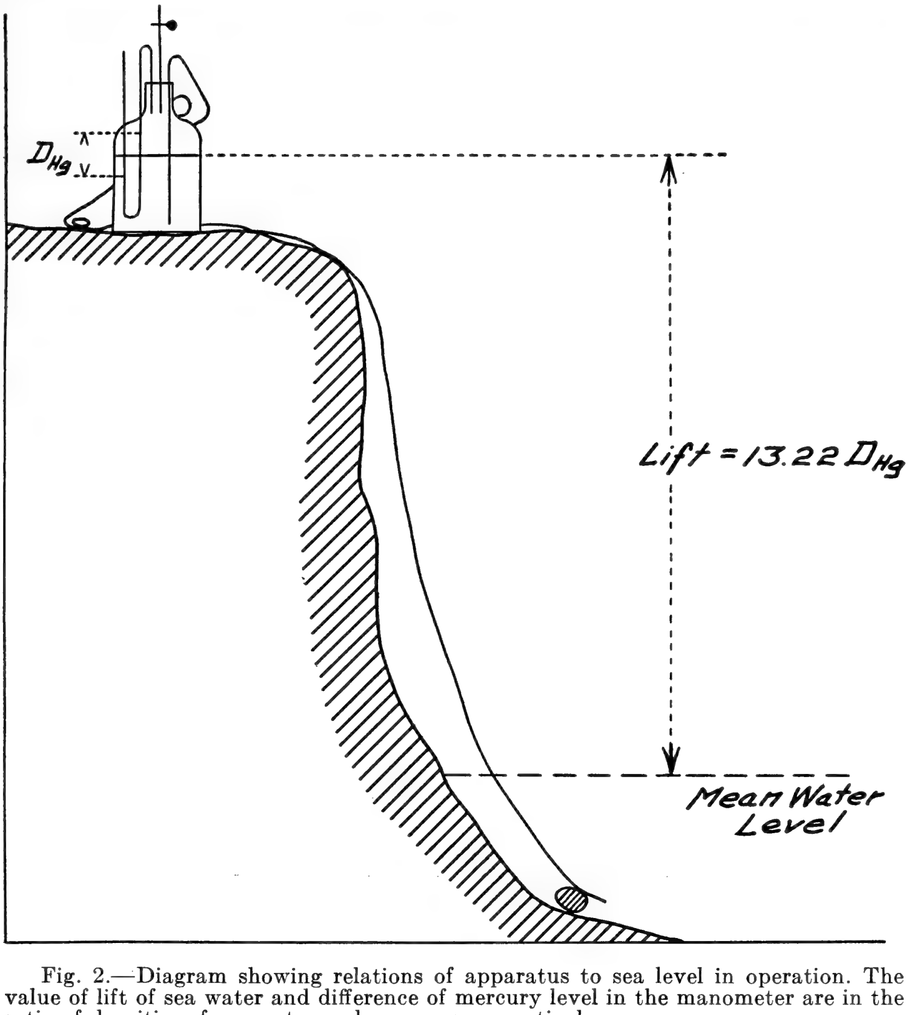

Fig. 2.—Diagram showing relations of apparatus to sea level in operation. The value of lift of sea water and difference of mercury level in the manometer are in the ratio of densities of sea water and mercury, respectively.

calibrated. A few measurements will readily determine enough points on a curve to achieve such a calibration, and determine the value of B in the formula

$$h = A\left(\frac{1}{t}\right)^B$$

where h is difference of head, t is time of flow, and A a constant fixed by the volume and size of the jet.

Both the dilatometer and the orifice types are practicable for casual single measurements by the operator from a standing position, whence a hand level sight can then be made. Naturally neither of them is so accurate or so convenient for a longer series of measurements in determining a semi-permanent bench mark as the manometer type. The manometer type also has the advantage that from 15 to 30 successive measurements may be made with a single filling of the jug, by venting the air chamber after each reading and waiting 1 to 2 minutes for a new balance to be reached.

PERFORMANCE OF THE MANOMETER TYPE. It will already have occurred to the reader that the results of any single measurement indicate only the difference between the water level in the reservoir and the contemporary level in the sea. Such a measurement has to be corrected by the amount by which such contemporary sea level lies above or below mean sea level. This is readily done by means of a table incorporated in the standard tide tables, or by graphic methods, given the time and height of adjacent high and low tides.

The following tables indicate the performance obtained with the manometer type of gage.

TABLE 1.—ACCURACY OF WATER LEVEL MEASUREMENTS[a]

Selection	Average No. readings in group	Maximum deviation, average	Absolute maximum deviation	Probable error single reading, average	Probable error single reading, extremes
Whole series 50 groups	4.5	0.13	0.30	0.057	0.143 0.011
Worst 10 groups[b]	4.2	0.24	0.30	0.110	0.143 0.092
Best 10 groups	3.9	0.045	0.07	0.021	0.027 0.011[c]

[a] 226 individual determination, 50 groups. Figures in feet.
[b] Includes several series taken when waves 4 and 5 feet high were running past the sea tube.
[c] Omitting a series of four identical readings, giving probable error of 0.000.

In view of the fact that most of the groups contain four readings, the probable error of the mean of readings in a given group is about half the probable error of a single reading.[2] Thus it appears that while

[2] Probable error of single reading $= .6745\sqrt{\dfrac{\Sigma d^2}{n}}$.

Probable error of mean of n readings $= \dfrac{.6745\sqrt{\dfrac{\Sigma d^2}{n}}}{\sqrt{n}}$.

exceptional single readings in a long series may vary from the contemporary mean water level by 0.3 feet, the expected error of a single reading (P.E.) is under 0.06 and the probable error of an average of four readings will commonly not exceed 0.03 feet. These are instrumental and manipulative errors; the value to be measured is the existing local contemporary water level, with such abnormalities as may result from winds, coastal configuration and the like.

It is recognized, especially through the recent work of Johnson[3] and others that mean sea level, or any other position of sea level fluctuations, is not at all a regular or uniform level or surface and that in its measurement in a standard or regional sense, or for comparisons with past or future positions, requires selection of a site as free as possible from local or temporary peculiarities. On the other hand physiographic and biologic features are formed in relation to the existing average or extremes of water level at a given time and place and it appears appropriate to measure such local datum surfaces. Indeed such locally measured sea levels may in places be more significant than a regional mean sea level established by precise level from a remote bench mark.

Aside from the instrumental errors made at a given time, the other chief source of error in fixing mean sea level locally from a short series of measurements is in computing the tidal stage at the time of measurement. In the writer's studies it has been assumed that the tide stages between adjacent high and low positions followed a sine curve. Thus the stage of tide can be computed by the formula

$$H_c = H_{cm} + \tfrac{1}{2}R_c\left(\quad \left[\frac{T_c - T_m}{\frac{1}{2}(T_{ht} - T_{lt})}\,\frac{\pi}{2}\right]\right)$$

where H_c is the contemporary tidal stage to be determined, H_{cm} the stage midway between adjacent high and low tide stages, R_c the difference between the adjacent extremes, and T_c, T_m, T_{ht}, T_{lt} the clock times of the contemporary observation, the time midway between adjacent extremes and times of high and low tide respectively. If algebraic signs are used strictly this formula applies; in most cases the proper sign of the last term will be apparent by inspection.[4]

In order to determine the validity of mean tide as computed from single short series of measurements made at random tidal positions, a total of 9 series of measurements was made at one readily accessible

[3] JOHNSON, D. W., *Studies of Mean Sea Level.* National Research Council, Bull. 70. 1929.

[4] A table for making these computations is also carried in the annual Tide Tables published by the Coast and Geodetic Survey.

station on the Oahu coast, just west of the Koko blow hole. Results of these measurements are shown in the following table.

TABLE 2.—SUCCESSIVE SEA LEVEL MEASUREMENTS AT ONE STATION

No.	Tidal time (fraction of interval before or after high tide)	Tidal stage	Lift	Elevation		Deviation from mean
				Above tidal datum	Above mean level	
1	+0.29	1.57	3.92	5.49	4.69	.07
2	−0.70	.18	5.30	5.48	4.68	.08
3	−0.23	1.72	3.92	5.64	4.84	.08
4	+0.16	1.45	4.07	5.52	4.72	.04
5	+0.22	1.37	4.16	5.53	4.73	.03
6	+0.27	1.29	4.20	5.49	4.69	.07
7	−0.07	1.88	3.78	5.66	4.86	.10
8	−0.03	1.90	3.71	5.61	4.81	.05
9	0.00	1.90	3.75	5.65	4.85[a]	.09

[a] Average for this column is 4.763.

Each of the determinations in the above table is the average of several individual measurements, in most instances, 12, and may be regarded as not over 0.01 or 0.02 in error as related to mean contemporary water level. Extreme variation in the determination of sea level is 0.10 feet; the standard deviation is 0.071 and the probable error of an individual determination is 0.048 feet. Both theory and practice indicate that errors are likely to be greater in measurements made in narrow, shallow inlets and in those made at low stages of tide.

At any rate it appears that with the low tidal range of Oahu (extremes, 3.0 feet) and with the moderate variations of water and air temperatures found in the tropics, mean water level may be determined within three or four hundredths of a foot in not over ten minutes with a readily portable apparatus. On coasts of greater tidal range errors in such brief measurements will be proportionately greater, but it may be presumed that here, with greater difficulty of making estimates, such measurements will be equally acceptable in this type of work. Also in higher latitudes more careful calibration at different temperatures may be required. If more precise measurements are required, the manometer type of gage is easily adapted to a long series of readings, which will reduce observational errors as desired and may be used to throw much light on the form of the tidal curve.

PALEOBOTANY.—*The genus* Glyptostrobus *in America.*[1] ROLAND W. BROWN, U. S. Geological Survey.

Glyptostrobus is a coniferous genus represented today by a single species, *G. pensilis* Koch, called water-pine, occurring only a few feet above sea-level near Canton and Foochow in the coast region of southeastern China. Like the maidenhair tree, *Ginkgo biloba* Linnaeus, the water-pine apparently no longer exists in the wild state, but is cultivated and protected. It is planted as a binder along the banks of canals and watercourses and as a windbreak on the outskirts of villages. Although somewhat smaller and less hardy than the swamp cypress, *Taxodium distichum* (Linnaeus) Richard, of the southeastern United States, the water-pine resembles the latter in general appearance, form, and habit. Both species produce deciduous annual branchlets, heterophyllous foliage, and, when growing in extremely wet situations, send up from their roots those conical, woody, breathing organs called "knees," upright in *Taxodium* but bent over in *Glyptostrobus*.

The resemblances between *Glyptostrobus* and *Taxodium* led to a confusion of at least one living species of *Taxodium*, *T. adscendens* Brongniart, with *Glyptostrobus pensilis;* but the differences between the two genera were clearly stated in 1926 by Henry and McIntyre,[2] so that now they may be readily distinguished as follows:

Glyptostrobus.—Leaves cupressoid on branchlets bearing flowers and cones; flowers and cones solitary and terminal on erect branchlets; cones persistent after ripening, pyriform, with overlapping, elongated, non-peltate scales attached to a disc at the base, without resin glands on inner face; seeds small, ovoid, with a long terminal wing; tracheids narrow; bordered pits on radial wall of tracheids, mostly uniseriate; bordered pits on tangential wall of tracheids in autumn wood, few and widely spaced; simple pits on radial wall of parenchyma cells, few, on tangential wall, none; terminal wall of parenchyma cell, thin; simple pits in each crossfield 2 to 6, mostly 3 or 4, oval, in one or two horizontal rows; wood rays 2 to 14 cells high, with thin terminal walls; transverse section shows resin cells arranged in 1 to 3 irregular bands.

Taxodium.—Leaves acerose on branchlets bearing flowers and cones; flowers and cones numerous and lateral on pendulous branchlets; cones disintegrating after ripening, globose or ellipsoid, with peltate scales fitting together at the edges, exhibiting a rhomboidal or diamond-shaped exposed face and having resin glands on inner face; seed large, triangular, without wing; tracheids almost twice the width of those in *Glyptostrobus;* bordered pits on radial wall of tracheids, mostly multiseriate; bordered pits on tan-

[1] Published by permission of the Director, U. S. Geological Survey. Received April 3, 1936.

[2] HENRY, AUGUSTINE, and McINTYRE, MARION. *The swamp cypresses, Glyptostrobus of China and Taxodium of America, with notes on allied genera.* Proc. Royal Irish Acad. **37**, sect. B, no. 13: 90–116. 8 pls. 1926.

gential wall of tracheids in autumn wood, more numerous than in *Glyptostrobus* and some closely spaced; simple pits on radial wall of parenchyma cells more numerous than in *Glyptostrobus,* on tangential wall may occur in autumn wood; terminal wall of parenchyma cell conspicuously thickened or nodose; simple pits in each crossfield 1 to 5, mostly 3, circular, in one

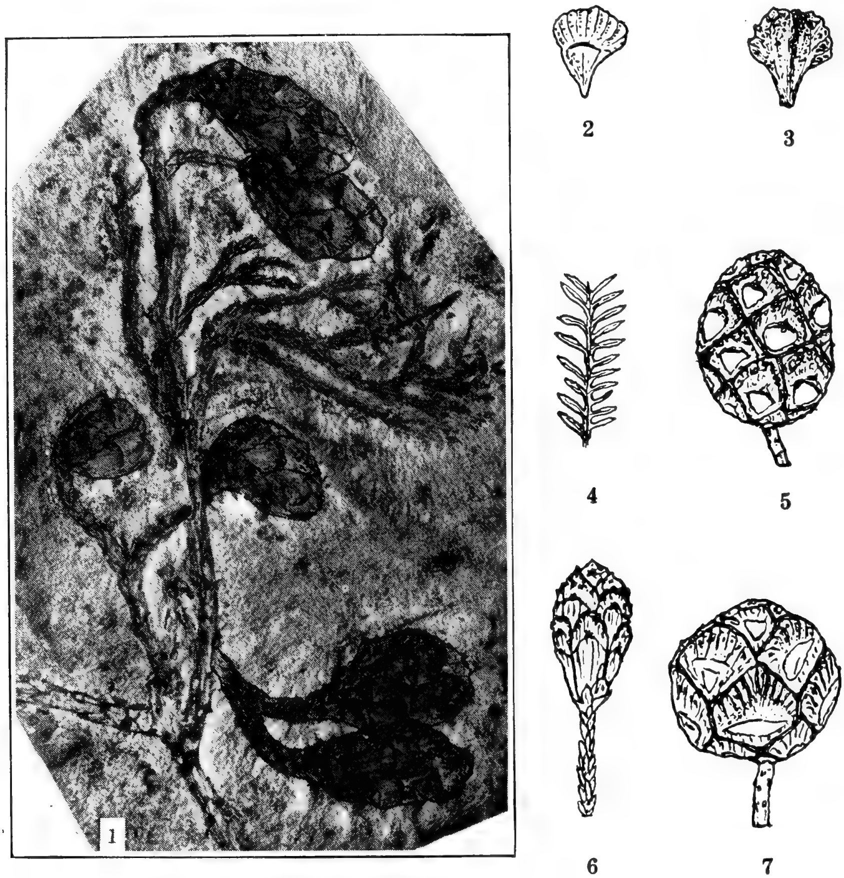

Fig. 1.—*Glyptostrobus oregonensis,* branch with cones and cupressoid foliage. Figs. 2, 3.—Cone-scales, outer and inner faces, respectively, of *G. dakotensis.* Fig. 4.—Cryptomeroid foliage of *G. dakotensis,* found with cone-scales, Figs. 2, 3. Fig. 5.—Cone of swamp cypress, *Taxodium distichum.* Fig. 6.—Cone of water-pine, *Glyptostrobus pensilis.* Fig. 7.—Cone of pond cypress, *Taxodium adscendens.* All figures natural size.

horizontal row; wood rays 2 to 20 cells high, with thick terminal walls; transverse section shows resin cells usually arranged in one band.

Although the living species, *Glyptostrobus pensilis,* can now be distinguished readily from species of *Taxodium* and other coniferous genera, the detection and separation of the fossil representatives of *Glyptostrobus* is fraught with considerable uncertainty. This is particularly true when foliage only is available. In the living species this

may be of three kinds—cupressoid, taxodioid, and cryptomeroid, in allusion to the typical foliage, respectively, of *Cupressus, Taxodium,* and *Cryptomeria.* A given fossil shoot or twig within this range might therefore merit any one of four interpretations, let alone being confused with other genera, such as *Sequoia, Cunninghamia, Torreya, Juniperus, Tsuga,* etc. Because of the uncertainty concerning the identity of such twigs as are ordinarily preserved in shale and sandstone, those recorded fossil species of *Glyptostrobus* based upon foliage alone will not be discussed here but will be regarded as doubtful identifications. Attention will be centered on those species purporting to be based upon authentic, characteristic cones or cone-scales.

The origin and early history of *Glyptostrobus* is shrouded in obscurity. A few species, based upon foliage, have been recorded from the Cretaceous of North America, Europe, and Australia, but these must be considered as of doubtful status until cones are discovered in association or connection with the foliage. From the Eocene onward, however, remains of cones or cone-scales in association with foliage have substantiated the presence of species of *Glyptostrobus* in the northern hemisphere, circumpolar in the Tertiary but later reduced to one species restricted to southeastern Asia.

Two Tertiary European species have been described—*G. europaeus* (Brongniart) Heer and *G. ungeri* Heer—but because the latter appears to be only a phase or variety of the former, the tendency now is to synonymize both, thus leaving *G. europaeus* as the only species to represent the genus during the Tertiary in the eastern hemisphere.[3]

In North America the first remains strongly suggesting *Glyptostrobus* are scattered cone-scales and cryptomeroid-cupressoid foliage, described from the Fort Union (Eocene) formation of North Dakota as *G. europaeus* by J. S. Newberry. For reasons that will be given immediately, I shall rename these specimens.

Glyptostrobus dakotensis, new name Figs. 2–4

Glyptostrobus europaeus (Brongniart) Heer. Newberry, J. S., U. S. Geol. Survey Mon. **35:** 24, pl. 26, figs. 6–8a; pl. 55, figs. 3, 4, 1898.

Remarks.—This species may be described as being different from *G. europaeus* in several specific respects: 1. The cone-scales are, on an average, shorter and broader. 2. The cone-scales occur scattered and detached, a characteristic apparently not shown by *G. europaeus* or by the living *G. pensilis,* whose cones remain intact and do not disintegrate readily after ripening. 3. The species occurs in the lower part of the American Eocene, a considerable time interval from typical *G. europaeus* in the European Miocene.

[3] See synonymy given by E. W. BERRY in *Lower Eocene floras of southeastern North America.* U. S. Geol. Survey Prof. Paper **91:** 169. 1916.

Occurrence.—Numerous localities in the Fort Union formation in North Dakota and Montana. Figured specimens in U. S. National Museum.

The collections made by I. C. Russell, in 1902, from light-colored, tuffaceous Miocene beds near Beulah, Malheur County, Oregon, contain numerous leaves of a chinquapin, *Castanopsis convexa* (Lesquereux) Brooks, and the coniferous branch with cones to be described here as

Glyptostrobus oregonensis, new name Fig. 1

Glyptostrobus linguaefolia (Lesquereux) Brooks. Brooks, Betty W., Annals Carnegie Mus. **24**: 281, pl. 4, fig. 6, 1935.

Remarks.—This is the specimen referred to by Brooks in her discussion of *G. linguaefolia*, cited in the synonymy, and said to be in the U. S. National Museum collections. It carries a number of small annual branchlets covered with cupressoid, lingulate foliage and terminated by characteristic pyriform, glyptostroboid cones averaging 2 cm in length, with elongated, imbricated scales. Similar twigs, but no cones, have been reported from approximately contemporaneous deposits on Sucker Creek near the Oregon-Idaho boundary.

The similarity of this specimen to the figures of *G. europaeus* (Brongniart) Heer[4] and *G. ungeri* Heer[5] is striking, but there are differences that, in my opinion, justify the segregation of it as a species distinct from the American Eocene *G. dakotensis* on the one hand and the European Miocene *G. europaeus* on the other: 1. The cones are longer and narrower, more pyriform. 2. The edges of the cone-scales are less crenulate, almost smooth.

A reexamination of the better preserved types of the Florissant species called *Sabina linguaefolia* (Lesquereux) Cockerell shows that the leaves are decussate or opposite in alternate pairs, a character that renders untenable their assignment to *Glyptostrobus* as proposed by Brooks. Lesquereux,[6] however, has recorded *G. ungeri* from the Florissant lake beds and is emphatic in saying that "the cones of the species . . . are not those of a *Sequoia* but of a *Glyptostrobus.*" The drawing (Lesquereux's Fig. 4), showing a branch with three cones, having imbricated cone scales, would seem to confirm his identification. At the close of his discussion Lesquereux says: "Very common at Florissant. The specimens figured are mostly those of the Princeton Museum." The specimen from which Fig. 4 was drawn does not, upon inquiry, seem to be in the collections either of the Princeton Museum or those of the American Museum of Natural History, where some of Lesquereux's types were deposited; and without examination of this specimen I am unwilling to affirm or deny that it is a species of *Glyptostrobus.* The possibility that the artist may have stretched a point, as artists sometimes do in response to wishful thinking (abetted perhaps by their employers), must be

[4] Heer, Oswald. *Flora tertiaria Helvetiae* **1**: 51, pl. 19; pl. 20, fig. 1, 1855.
[6] Ibid., **1**: 52, pl. 18; pl. 21, fig. 1.
[5] Lesquereux, Leo. *The Cretaceous and Tertiary floras.* U. S. Geol. Survey Terr. Rept. **8**: 137, pl. 22, figs. 1–6a, 1883.

considered, for only the uppermost cone purports to have imbricated scales; the other cones resemble those of *Sequoia affinis* Lesquereux.[7] The statement, "Very common at Florissant," is not confirmed by the large Florissant collection of the U. S. National Museum or by that of the Princeton Museum, which do not contain a single such cone with imbricated scales; but do contain numerous examples of *Sequoia affinis*, whose cones resemble in size and shape those of the alleged *Glyptostrobus ungeri* of Lesquereux's Fig. 4. I, therefore, shall await the rediscovery of the type specimen of Fig. 4, or the finding of specimens equivalent to it, before passing final judgment. Theoretically, *Glyptostrobus* would probably not be out of place in the Florissant flora.

Associated with *G. oregonensis* in the same beds is a chinquapin, *Castanopsis convexa*, whose living relatives are found in western California and Oregon, particularly in the humid coast valleys; and in southeastern Asia. At elevations of 5,000 feet or more on the west slopes of the Sierras the species become shrubby. Does the fact that species of *Castanopsis* and a species of *Glyptostrobus* now survive at or near sea-level in southeastern Asia mean that eastern Oregon, where the fossils were found, was, at the time the plants were entombed, at or near sea-level? Or were those species adapted to higher elevations and a more rigorous climate?

The statement that "the plant-bearing beds at Beulah are younger than the Payette, and, although the evidence is not all that could be wished, are referred to the upper Miocene (corresponding with the Mascall beds of Merriam, in John Day Valley, Oregon)"[8] will have to be taken for what it is worth until it is learned definitely by careful mapping and paleontologic comparisons what the terms Payette and Mascall now include and to what they should be limited. My recent tentative opinion[9] was to the effect that a part, at least, of the Payette is lower Miocene and that some localities in the Mascall are upper Miocene. To this should be added that other parts of what is now called Payette may be middle or upper Miocene and that some localities now called Mascall may be middle Miocene.

Occurrence.—Miocene beds near Beulah, and on Sucker Creek, Malheur County, Oregon. Figured specimens in U. S. National Museum.

According to present information, the foregoing species, *Glyptostrobus dakotensis* from the Eocene, and *G. oregonensis* from the Miocene, appear to be the only species that can be clearly differentiated as *Glyptostrobus* among the plant fossils of the western hemisphere. Apparently the genus became extinct in North America sometime late in the Tertiary.

[7] LESQUEREUX, LEO. *The Tertiary flora.* U. S. Geol. Survey Terr. Rept. **7**: 75, pl. 7, figs. 3–5; pl. 65, figs. 1–4, 1878.

[8] RUSSELL, I. C. *Notes on the geology of southwestern Idaho and northwestern Oregon.* U. S. Geol. Survey Bull. **217**: 63. 1903.

[9] BROWN, ROLAND W. *Miocene leaves, fruits, and seeds from Idaho, Oregon, and Washington.* Jour. Paleont. **9**: 586. 1935.

BOTANY.—*New plants mainly from western South America*—V.[1]

ELLSWORTH P. KILLIP, U. S. National Museum.

The present paper contains descriptions of three new species, one from the upper Amazon basin, collected by the National Geographic Society's expedition to the headwaters of the Orinoco River, and two from the historic Mutis Herbarium[2] at the Jardín Botánico, Madrid, which has recently become available for study. In addition, four new combinations of names are made, and a new name is substituted for an invalid one.

Piratinera mollis Killip, sp. nov.

Arbor, ramis demum glabris; folia oblonga, apice acuminata, supra subscaberula, in costa sparse puberula, subtus dense et molliter pilosula, pilis divaricatis, nervis lateralibus 8–10-jugis; pedunculi axillares, puberuli; receptaculum depresso-hemisphaericum, bracteis orbiculatis vel subreniformibus, peltatis, ciliolatis; flores ♀ 2, stigmata 2.

Tree; young branches very slender, brown, sparingly or densely pilosulous, the older glabrous; petioles 1 to 2 mm long, densely pilosulous; leaves oblong, 3 to 7 cm long, 1.5 to 3 cm wide, sharply and subabruptly acuminate at apex, rounded-cuneate and unequal at base, coriaceous or subcoriaceous, above dark green and lustrous, slightly scaberulous, sparingly puberulous on midnerve, beneath pale, densely and softly pilosulous throughout, with spreading, curved or straight hairs, the principal lateral nerves 8 to 10 pairs, united near margin, prominulous above, slightly elevated beneath; peduncles axillary, solitary, 2 to 3 mm long, erect or recurved, puberulent; receptacle depressed-hemispheric, 4 to 5 mm in diameter, covered throughout with orbicular or subreniform, peltate, ciliolate, glabrescent or sparingly puberulent bracts 0.5 to 1 mm in diameter; staminate flowers not seen; pistillate flowers 2, the stigmas 2, about 1.2 mm long, elevated above the scales.

Type in the U. S. National Herbarium, no. 1,563,014, collected in Colombia, between 1760 and 1808, by José Celestino Mutis (no. 365). Duplicate at Madrid. This species is also represented by *Mutis* 362 (U. S. N. H. and Madrid).

In Blake's key to the species of this genus[3] the proposed new species would come nearest *P. acutifolia* because of the spreading hairs on the under surface of the leaves and the long sharp leaf tips. It differs from that plant in having much smaller leaves with fewer lateral nerves, a much smaller receptacle, and larger bracts.

Inga caudata Killip, sp. nov.

Ramuli et folia juvenilia rufo-hirtella, demum glabra; petiolus et rachis anguste alata, glandulis sessilibus; foliola 3-juga, oblanceolata, caudato-acuminata, subauriculata, membranacea; flores brevispicati; calyx anguste

[1] Published by permission of the Secretary of the Smithsonian Institution. For preceding parts see this Journal **16**: 565–573. 1926; **19**: 191–195. 1929; **21**: 347–353. 1931; **24**: 42–52. 1934. Received April 30, 1936.

[2] See Killip: *A scientific resurrection: the Mutis Herbarium at Madrid.* Bull. Pan Am. Union, March 1933, pp. 162–171.

[3] This JOURNAL **12**: 395. 1922.

tubulosus, glaber, lobis late ovatis; corolla tenuis, adpresso-flavo-hirsuta; tubus staminalis exsertus.

Branchlets and foliage sparingly rufo-hirtellous when very young, soon glabrous; petiole and leaf-rachis narrowly winged, the wings up to 2 mm wide, the glands sessile, concave, 1 to 1.5 mm wide; leaflets 3 pairs, oblanceolate (uppermost) or ovate-oblong (lower), up to 15 cm long and 4 cm wide, caudate-acuminate, gradually narrowed to a subauricular base, short-petioluled, membranous, the nerves rather prominent beneath; peduncles and rachis of inflorescence about 6 cm long, slender, glabrous or very sparingly pilosulous, the flowers short-spicate; calyx narrowly tubular, about 1 cm long and 2 mm in diameter, glabrous, striate, the lobes broadly ovate, obtuse; corolla slender, 2.5 cm long, 1.5 mm wide, appressed-flavo-hirsute, the lobes ovate-lanceolate, 3 mm long, acute; stamen tube exserted about 8 mm, the free filaments 2 cm long.

Type in the U. S. National Herbarium, no. 1,517,914, collected on the Rio Maturacá, below Salto de Huá, State of Amazonas, Brazil, December 10–12, 1930, by E. G. Holt and E. R. Blake (no. 531).

This species is related to *I. longiflora* Spruce and *I. micradenia* Spruce. From both it differs in having caudate leaflets; the uppermost leaflets are oblanceolate, not oblong or ovate-elliptic as in its two relatives. The flowers are smaller and slenderer than in *I. longiflora;* and the stamen tube is long-exserted, whereas in *I. micradenia* it is included.

Parosela carthaginensis (Jacq.) Killip, comb. nov.

Psoralea carthaginensis Jacq. Enum. Pl. Carib. 27. 1762; Stirp. Amer. 206. 1763.
Psoralea enneaphylla L. Sp. Pl. ed. 3, 1076. 1764.
Psoralea emphysodes Jacq. Coll. **4**: 144. 1790.
Dalea enneaphylla Willd. Sp. Pl. 1338. 1800.
Psoralea emphysodes Rydb. N. Amer. Fl. **24**: 113. 1920.

Jacquin's first description of *Psoralea carthaginensis,* in the Enumeratio is brief, "Psoralea foliis pinnatis; spicis axillaribus. Pluk. Phyt. t. 166. f. 2." A much amplified description was published the following year (1763) by Jacquin, Plukenet's description and figure of "Colutea enneaphyllos . . . " being cited. Under *Psoralea enneaphylla* L. (1764) Linnaeus quotes the first Jacquin description and cites the Plukenet reference. So far as can be determined Plukenet's figure represents a plant identical with the one common in northern South America, so that *Psoralea enneaphylla* is a mere substitution for *Psoralea carthaginensis.*

Specimens recently collected by Heriberto (no. 283) from the type locality, Cartegena, by Killip and Smith (no. 14448) from the vicinity of the neighboring village Turbaco, and by Pennell (no. 4060), from the same department, agree perfectly with Jacquin's description, and I can see no reason for longer postponing the transferal of Jacquin's name.

The typical form of *P. carthaginensis* has essentially glabrous branches and leaves, the leaves having 4 to 6 pairs of leaflets. Other specimens from Colombia and Venezuela have up to 9 pairs of leaflets, which, with the

branches, are more or less pilosulous. These, I believe, are mere variants of *P. carthaginensis,* and I am confident that some, if not all, of the following will eventually have to be reduced to synonyms of this species: *Psoralea phymatodes* Jacq., *Dalea phymatodes* Willd., *Dalea vulneraria barbata* Oerst., *Parosela barbata* Rydb., *Dalea domingensis* DC. and *Parosela domingensis* Millsp.

I am purposely transferring this species to *Parosela* rather than to *Dalea* in the hope that attention will be called to the unfortunate inclusion of *Dalea* in the list of Proposed Conserved Generic Names.[4] The genus is wholly a New World one, and the choice of a name is primarily a matter of concern to American botanists. Macbride has well stated[5] the case for *Parosela.* It is the name adopted by Rydberg in the North American Flora (178 species), by Standley in the Trees and Shrubs of Mexico (106 species), and by Macbride in a revision of the perennial South American Paroselas[6] (33 species). If *Dalea* is conserved, it will be necessary to make new combinations for 80 to 90 species, assuming that all are valid. If the species in the small genera segregated from *Parosela* by Rydberg are placed in *Dalea,* 10 will require new combinations; if in *Parosela,* only four. It is sincerely hoped that the Committee on Nomenclature, which is scrutinizing the proposed conserved names, will reject *Dalea.*

Tephrosia carpinteri (Rydb.) Killip, comb. nov.

Cracca carpinteri Rydb. N. Amer. Fl. **24**: 172. 1923.

Tephrosia gracillima (Robinson) Killip, comb, nov.

Cracca angustissima Vail, Bull. Torrey Club **22**: 32. 1895. Not Kuntze (1891).
Tephrosia ambigua gracillima Robinson, Bot. Gaz. **28**: 201. 1899.
Cracca gracillima Heller, Cat. N. Amer. Pl. ed. 2, 7. 1900.

Derris pterocarpus (DC.) Killip, comb. nov.

Deguelia scandens Aubl. Pl. Guian. Franç. **2**: 750. *pl. 300.* 1775.
Lonchocarpus? pterocarpus DC. Prodr. **2**: 260. 1825.
Derris guianensis Benth. Journ. Proc. Linn. Soc. Bot. **4**: Suppl.: 106. 1860.
Derris scandens Pittier, Contr. U. S. Nat. Herb. **20**: 41. 1917. Not *Derris scandens* Benth. (1860), an Asiatic species.

Derris being a conserved name, the above change in nomenclature for the American plant, sometimes known as *Derris guianensis* or *Deguelia scandens,* is necessary. In monographing Dalbergieae, Bentham proposed the name *Derris guianensis* for this American species, citing *Lonchocarpus pterocarpus* DC. as a synonym. Although De Candolle's description is rather brief, there can be little doubt but that it applies to this plant, and his specific name is the earliest one available.

This is one of the important fish poisons in northern South America.

[4] *Nomina generica conservanda proposita.* Int. Rules of Bot. Nomencl. p. 135. 1935.
[5] Field Mus. Bot. **4**: 100. 1927.
[6] Field Mus. Bot. **4**: 99–113. 1927.

Gouania podocephala Killip.

Gouania ulmifolia Tr. & Planch. Ann. Sci. Nat. V. Bot. **16**: 382. 1872. Not Hook. & Arn., 1833.

Voyria macrantha Killip, sp. nov.

Caulis crassus, prope apicem ramis 1–2 brevibus; squamae ovatae, apice rotundatae, per partem tertiam connatae; calycis tubus cylindrico-campanulatus, lobis 5, late ovatis, rotundatis; corolla rubro-purpurea, extus ad basin glabra, ad apicem puberulenta, intus pulverulenta, limbo rotato, 4 to 5 cm lato, ad faucem lobato, lobis 5, obovatis vel rhombeo-obovatis, obtusis; antherae ovatae; capsula ovoidea.

Stem stout, 6 to 7 cm high, about 2 mm thick, erect, once-branched near apex, glabrous; scales opposite, 6 to 12 mm apart, ovate, 3 to 6 mm long, rounded, connate in lower third, the sinus acute; peduncles up to 13 mm long, stout, gradually widening to calyx; calyx tube cylindric-campanulate, about 1.5 cm long, 5 to 6 mm wide at throat, the lobes 5, broadly ovate, 1.5 to 2 mm long, 3 to 4 mm wide, rounded, minutely ciliolate, glabrous otherwise; corolla bright red-purple, the tube cylindric, 3.5 to 4.5 cm long, glabrous at base without, puberulent on upper half without, pulverulent within; the limb rotate, 4 to 5 cm wide, lobed to throat, the lobes 5, obovate or rhombic-obovate, 2 to 2.4 cm long, 7 to 11 mm wide, obtuse; filaments inserted about 5 mm below throat of tube, 0.5 to 1 mm long; anthers ovate, 1 to 1.5 mm long; style slender, about 3.7 cm long; stigma capitate, papillose on upper surface, smooth beneath; ovary sessile; capsule ovoid, 1 cm long, 6 mm in diameter.

Type in the herbarium of the Jardín Botánico, Madrid, collected in Colombia, between 1760 and 1808, by José Celestino Mutis (no. 3054). Represented also by *Mutis* 2566. Known also from the following Colombian collections:

Dept. Sur de Santander: " Camp Carare II," *Haught* 1621 (U.S.N.H.). "Camp Aguila," Carare Valley, *Haught* 1871 (U.S.N.H.).

The flowers of *V. macrantha* are much larger than in other species of *Voyria* or in the closely related genus *Leiphaimos*. Apparently the species comes nearest *V. caerulea* Aubl. but in addition to having larger flowers than *V. caerulea*, the scales and the calyx lobes are rounded, not acute.

ZOOLOGY.—*Radular movement in gastropods.*[1] Gordon Gunter, Bureau of Fisheries. (Communicated by Paul S. Galtsoff.)

Cuvier[2] in 1817 described the radula in gastropods as a passive instrument moved secondarily by its supporting cartilages. Huxley[3] (1853) disagreed with him and maintained that the radula executes movements independent of its cartilages and moves over them "chain-saw-like." He believed that this type of movement prevailed "throughout the Cephalopoda and Gasteropoda." Most of his argument was

[1] Printed by permission of the Commissioner of Fisheries. Received February 20, 1936.

[2] Memoire pour servir a l'histoire et a l'anatomie des mollusques. Paris. 1817.

[3] Phil. Trans. Roy. Soc. London **143**: 29–65. 1853.

based on anatomical structure, but he stated that the apparatus could "be seen working in *Firoloides* and *Atlanta*."

Most writers in describing the odontophoral apparatus in gastropods have not mentioned the issue, but there have been adherents of both theories. Lacaze-Duthiers[4] (1856), Geddes[5] (1879), Amaudrut[6] (1898) and Simroth[7] (1901) rejected Huxley's hypothesis for that of Cuvier, either by direct statement or by implication in their descriptions. Geddes studied under Huxley and took up the subject at the latter's instigation. He rejected the chainsaw idea and concurred with Cuvier. His objection to Huxley's theory was based principally on the close attachment of the radula to the radular sac by the radular membrane and his belief that the radula could not slide over the acute angle formed by the apex of the cartilages.

Wegman[8] (1884) in describing *Haliotis* stated that the radular membrane slides over the cartilages, which implies that the radula does also. Herrick[9] (1906) in describing the anatomy of the odontophore of *Busycon canaliculatus* sided with Huxley, and gave a very clear exposition of his conception of its mode of action. Dakin[10] (1912) working on *Buccinum* also followed Huxley. He stated that the radula could be made to slide over the cartilages in narcotized animals by pressing the proboscis between the thumb and forefinger. Both he and Herrick stated as further evidence for their belief, that radular movement could be felt when animals were induced to rasp the finger tip. The writer has repeated this experiment with *Melongena corona* and *Thais floridana*, but has found it impossible to tell by such means whether the radula slides or is passively borne by the cartilages.

Because of the internal position of the radula in the radular sac within the proboscis, its small size, and the fact that when in use the whole proboscis is often covered by the foot and its open end is placed on the food, observation of the living animal in the natural state seems to be almost impossible. These obstacles are probably the reasons why such observations, which would have settled the question, have been few and relatively incomplete. Some workers have stated that they have observed living animals, but most of their conclusions appear to be drawn from the anatomy, and the writer has not found

[4] Ann. Sci. Nat. **6**: 225–281. 1856.
[5] Trans. Zool. Soc. London **10**: 485–491. 1879.
[6] Ann. Sci. Nat. **7**: 1–291. 1898.
[7] Bronn's Klassen und Ordnungen des Thier-Reichs. Band 3. Leipzig. 1901.
[8] Arch. Zool. Exper. et Gen. **2**: 289–378. 1884.
[9] Amer. Nat. **40**: 707–737. 1906.
[10] Liverpool Marine Biology Committee Memoirs **20**: 1–115. 1912.

a complete description of radular movement based on direct observations of the odontophoral mechanism at work in the living animal.

Fasciolaria gigantea of the Florida coast is an ideal animal for study and observations were made on it at the Indian Pass Laboratory of the United States Bureau of Fisheries. It is one of the largest gastropods in the world and has a radula 2 mm. wide. When stimulated by a bit of oyster meat it gives the usual food reaction of carnivorous gastropods which culminates in the extrusion of the proboscis. This has been described in detail by Copeland[11] for *Nassa obsoleta* and *Busycon canaliculatum.* If the food is withdrawn the odontophore may be seen through the proboscis opening, with the naked eye, to continue working in the following manner. The cartilages bearing the radula move forward and upward with a licking motion. At the same time the radula moves upward and over the cartilages like a chainsaw or belt over a pulley, with a motion so rapid that it gives the illusion of rapid rotation. When the odontophore reaches the end of the forward movement it begins to move downward and backward. At the same moment the radula reverses its direction, almost too speedily for detection, and slides downward and under the cartilages. As the forward movement of the cartilages is started again the radula repeats the movement first described. The whole process proceeds at an even rate so that the radula has the appearance of a rapidly spinning wheel being carried back and forth on a frame. As Herrick (op. cit. p. 721) has pointed out the teeth are folded together as they pass back and forth under the cartilages and rasping can only be done during the upward stroke. The mouth is situated so that food can be drawn into it only by this movement and not by the downward one. In *Thais* the food may be seen to progress down the proboscis in peristaltic waves, which are apparently timed and initiated by the piston-like strokes of the odontophore.

The objections of Geddes and others to the theory that the radula has motion independent of that of the cartilages, were based on anatomical studies and cannot hold in the face of observations to the contrary on living animals. He seemed to disregard the significant fact that the radula is a long, ribbon-like, jointed apparatus, borne on a very flexible membrane; the whole being eminently fitted for the band-over-pulley type of function. The plates bearing the teeth are loosely joined together so that the whole radula can bend back upon itself. This jointed structure allows the radula to move over the apex

[11] Jl. Exp. Zool. **25**: 177–227. 1918.

of the cartilages as described for *Fasciolaria*. The radula is not too closely attached to the radular sac, as Geddes stated, or too firmly attached to the cartilages for independent movement, as shown by the fact that in *Thais floridana* and *Thais sp.* the radula of an amputated proboscis can be made to move over the cartilaginous support while the latter is perfectly stationary. These animals are very similar in structure to *Buccinum*, one species upon which Geddes worked and arrived at the opposite conclusion.

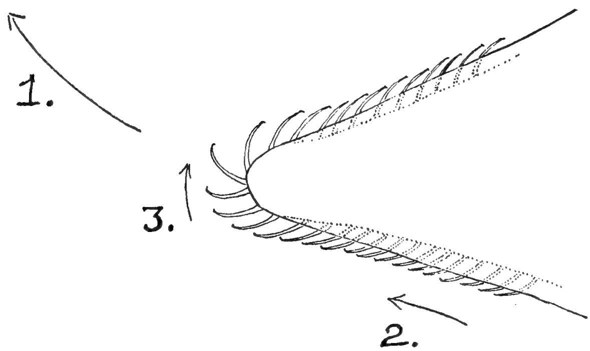

Fig. 1.—Diagrammatic side view of radula.

These studies apparently prove the hypothesis of Huxley and his adherents concerning the band-over-pulley movement of the radula. Yet Huxley (op. cit. p. 31) stated that "the buccal cartilages take no part in the movement of the tongue-plate." As shown in the above observations this is incorrect, at least for the forms described here. Von Siebold (quoted by Huxley, loc. cit.) had previously recognized that the cartilages play a part for he stated that by protrusion and retraction this organ is used by the Cephalophora as an ingestive apparatus. Oswald[12] (1893) seems to have first realized that both movements were concerned, although he said the band-over-pulley motion was very limited.

The illusion that a radula in operation is a small wheel is very significant, for it can be shown by reference to the description above and the accompanying diagram that the radula is functionally a small, rapidly rotating wheel or drum covered on the outside with small spikes.

As the cartilaginous frame moves forward and upward its trajectory is that of an arc as shown by arrow number 1 of the diagram. At

[12] Jen. Zeitschr. f. Naturw. **28**: 119–162. 1893.

the same time the radula is pulled up and over the apex of the cartilages by the radular muscles in the direction shown by arrow 2. This imposes a second speed on the first. The teeth sliding over the apex are held at right angles to the ribbon and pulled in the arc shown by arrow 3. From the simple law that the speed of a turning wheel is greatest at its circumference, it is seen that the barbs of the teeth at this point are moving at a greater speed than the ribbon itself or the teeth at any other point of the radula. This superimposes a third speed upon the other two, and it is easily seen how the illusion of a rotating wheel is created. This simple mechanical adaption moves the functional part of the radula at a rapid, but undetermined speed, and probably accounts to a large extent for the ability of many gastropods, such as *Thais, Murex, Eupleura, Urosalpinx* and *Buccinum* to bore through the hard shell of other mollusks. It is also possible that the radula is assisted by an acid secretion which softens the shell.

The distinctive structure of the odontophoral apparatus and its similarity in prosobranchiate gastropods leads the writer to believe that this mode of radular movement is typical for most prosobranchs and probably many other gastropods. Observations on *Thais floridana, Thais sp.*, and *Melongena corona* substantiate this hypothesis.

The writer is indebted to Dr. A. S. Pearse for the specimens of *Fasciolaria.*

ZOOLOGY.—*Copepods from the far north collected by Capt. R. A. Bartlett.*[1] CHARLES B. WILSON, Westfield, Massachusetts. (Communicated by MARY J. RATHBUN.)

For several years Capt. R. A. Bartlett has been gathering plankton from the coasts of Labrador, Canada and Greenland, the last cruise taking place during the summer of 1935. The samples thus accumulated have been submitted for examination by the National Museum and the copepods found in them are here listed. The localities from which the plankton was obtained may be conveniently divided into four groups according to geographical location. The first group extended along the entire coast of Labrador from 52 to 60 degrees North Latitude, and included several fishing and whaling grounds. The second group began at the mouth of Hudson Strait, just north of Labrador and extended northwest up the strait into the northern end of Hudson Bay, and thence into Fox Channel, a northern arm of the bay reaching into the Arctic Zone south of Baffin Island. In this

[1] Received March 18, 1936.

group a surface haul taken in the Bay of Gods Mercy on the south shore of Southampton Island, between Hudson Bay and Fox Channel, was remarkable for the number of southern species found in it. Other surface hauls were made while at anchor off the mouth of Fury and Hecla Strait during a furious gale of wind and snow. In these hauls the number of harpactids, usually found only close to the bottom, suggests that the violent agitation of the water during such a gale thoroughly mixes plankton that otherwise might be arranged more or less in layers. The third group embraced Davis Strait, Baffin Bay, the west coast of Greenland, and the straits which separate Greenland from Ellesmere Island from 76 to 78 degrees North Latitude. The fourth group ran along the east coast of Greenland north to the polar ice cap, with one or two stations between Greenland and Spitzbergen.

During the early cruises hauls were made with a dredge at or near the bottom and these seldom contained development stages. During the summer of 1935 a fine-meshed net was used, nearly always at the surface, and all of these hauls contained abundant development stages of copepods, crabs and Euphausiids. An effort was made to take these hauls at regular intervals during the entire twenty-four hours. As a result the plankton contains not only species regularly frequenting the surface during the daytime but also the diurnal migrants which come up from below during the night.

All the localities here recorded are in regions which have been hitherto examined but little for plankton. The lists of copepods here given furnish an interesting supplement to Willey's *Hudson Bay copepod plankton* (Contrib. Canadian Biol. and Fisheries, n.s., vol. 6, no. 25), since they reach farther north into the Arctic Circle. For this reason the lists are well worth publishing though they do not contain any new species.

Again, our knowledge of the geographical distribution of all but a very few species is extremely limited, and new localities are here recorded for nearly every species listed. Some found hitherto only on the coast of Norway or around Franz-Josef Land or Spitzbergen are here revealed far to the west and may well become circumpolar eventually.

Willey has called attention to the presence of Arctic copepods in Passamaquoddy Bay (Amer. Acad. Arts & Sci., vol. 56, no. 5). In these lists we find the exact reverse, the presence of temperate species far within the Arctic Circle. Evidently we cannot as yet fix with complete accuracy the north and south limits of very many species.

The results of this study are presented as a simple faunal list in which the species are arranged alphabetically in each locality. Following this list are notes on the several groups of copepods represented in the collection, Calanoida, Harpacticoida, Cyclopoida, and Notodelphyoida.

STATIONS ALONG THE COAST OF LABRADOR

HAWKES HARBOR. 53° North. Shallow water within the harbor. Dredge tow at the bottom. August 26, 1929. *Calanus finmarchicus, Dactylopusia signata, D. vulgaris, Ectinosoma neglectum, Metridia longa, Oïthona similis, Oïthonina nana, Paracalanus parvus, Pseudocalanus elongatus, Tisbe furcata.*

HAWKES ISLAND. 53° North. Whaling ground 30 miles off shore. Dredge tow at bottom, net tow at surface. August 31, 1929. *Calanus finmarchicus, C. hyperboreus, Harpacticus chelifer, Oithona similis, Oithonina nana, Paracalanus parvus, Pseudocalanus elongatus, Temora longicornis, T. stylifera.* Development stages of copepods and crabs at surface.

RED ISLAND. 53° North. Shallow water near shore. Net tow at the surface. August 26, 1929. *Calanus finmarchicus, C. hyperboreus, Oithona similis, Pseudocalanus elongatus.* Crab zoëas and megalops very abundant.

BEN'S COVE, CAPE AILLIK. 55° North. Shallow water within the cove. Surface tows during the day and at night. September 17, 1929, August 16, 17, 1935. *Acartia clausii, A. longiremis, Calanus finmarchicus, C. hyperboreus, Farranula carinata, F. rostrata, Laophonte elongata, Oithona similis, O. spinrostris, Oncaea borealis, O. venusta, Paracalanus parvus, Pseudocalanus elongatus, Temora longicornis, T. stylifera.* Development stages, especially *Calanus, Oithona, Temora.*

KAIG-LA-PAIT BAY. 56° North. Shallow water within the bay. Surface tows during the day. September, 1929. *Calanus finmarchicus, C. hyperboreus, Oïthona similis, Paracalanaus parvus, Pseudocalanus elongatus, Temora longicornis, T. stylifera.*

MUGFORD BAY. 58° North. Shallow water within the bay. Dredge tows at the bottom. September 4, 5, 1929. *Calanus finmarchicus, C. hyperboreus, Paracalanus parvus, Pseudocalanus elongatus.*

MOUTH OF HUDSON STRAIT. 59° North. Deep water off shore. Dredge tow at the bottom. July 25, 1933. *Cyclopina schneideri, Dactylopusia vulgaris, Ectinosoma neglectum, Parathalestris jacksoni, Pseudobradya minor, Tisbe furcata.*

CANADIAN STATIONS

BAY OF GODS MERCY, SOUTHAMPTON ISLAND. 64° North. Shallow water in the bay. Both day and night tows while at anchor in the bay. August 5, 1933. *Acartia clausii, A. longiremis, Bradypontius magniceps, Calanus finmarchicus, C. tonsus, Clausocalanus arcuicornis, Corycaeus anglicus, Dactylopusia tisboides, D. vulgaris, Farranula carinata, F. rostrata, Harpacticus uniremis, Laophonte elongata, L. perplexa, Oithona similis, O. spinirostris, Oncaea borealis, O. venusta, Paracalanus parvus, Pseudobrada minor, Pseudocalanus elongatus, Pseudocyclops obtusatus, Robertsonia tenuis, Tisbe gracilis, T. furcata, Undinula darwini, Zaus abbreviatus, Z. spinatus, Zosime typica.* Development stages.

MOUTH OF FROZEN STRAIT. 66° North. Surface tows in the strait and in Fox Channel. August 14–16, 1933. Strait half frozen across. *Acartia clausii,*

A. longiremis, Ameira longipes, A. tau, Calanus finmarchicus, Cyclopina schneideri, Danielssenia typica, Dactylopusia signata, Ectinosoma curticorne, E. neglectum, Laophonte elongata, Mesochra pygmaea, Oithona similis, Oncaea borealis, Paracalanus parvus, Pseudobradya similis, Pseudocalanus elongatus, Pseudothalestris pygmaea, Robertsonia tenuis, Rhynchothalestris helgolandica, Temora longicornis, Thalestris gibba, Tisbe furcata, T. minor, Zaus abbreviatus, Z. spinatus. Abundant development stages of crabs and copepods.

FOX CHANNEL. 66° to 67° North off Cape Penryhn, Melville Peninsula. Dredge tows at bottom and net tows at surface. August 27–30, 1933. *Acartia clausii, Alteutha depressa, Arctopontius expansus, Arctotrogus orbicularis, Ascomyzon intermedium, Botryllophilus inaequipes, Bradypontius caudatus, B. groenlandicus, B. magniceps, Calanus finmarchicus, C. hyperboreus, C. tonsus, Clausocalanus arcuicornis, Cyclopina schneideri, Dactylopusia signata, Dermatomyzon nigripes, Doropygella thorellii, Dyspontius striatus, Hemicyclops purpureus, Laophonte elongata, L. horrida, Lichomolgus agilis, Metridia longa, Myzopontius pungens, Oithona similis, Parartotrogus arcticus, Parathalestris jacksoni, Pseudobradya minor, Pseudocalanus elongatus, Pseudomolgus groenlandicus, P. leptostylis, Robertsonia tenuis, Thalestris gibba, Tisbe furcata.*

FURY AND HECLA STRAIT. 70° North. Anchored off Esquimaux village. Surface tows, midnight to 8 A.M. in a furious gale of wind and snow. September 7, 1933. *Acartia clausii, A. longiremis, Amallophora typica, Ameira longipes, A. tau, Amphiascus minutus, Bradypontius caudatus, Calanus finmarchicus, C. hyperboreus, C. tonsus, Clausocalanus arcuicornis, Cletodes tenuipes, Cyclopina elegans, Dactylopusia signata, Ectinosoma curticorne, E. neglectum, Farranula rostrata, Laophonte perplexa, L. similis, Mesochra pygmaea, Microsetella norvegica, Oithona similis, Oncaea borealis, Paracalanus parvus, Parathalestris jacksoni, Pseudobradya minor, P. similis, Pseudocalanus elongatus, Pseudomolgus groenlandicus, Pseudothalestris nobilis, P. pygmaea, Robertsonia tenuis, Thalestris gibba, Tisbe finmarchica, T. furcata, Zaus abbreviatus, Z. spinatus.* Development stages of crabs, copepods, and Euphausiids.

DAVIS STRAIT, BAFFIN BAY, AND WEST COAST OF GREENLAND

DAVIS STRAIT. 64° 47′ North. Mouth of the strait. Surface tow taken amid floating ice, 3:15 P.M. September 12, 1935. *Acartia clausii*, one male; *Calanus finmarchicus*, copepodid stages, few adults; *Oithona similis*, all adults, the females with ovisacs; *Paracalanus parvus*, two adults.

DAVIS STRAIT. 69° 18′ North. Surface tow, 6 A.M., raining. September 4, 1935. *Calanus finmarchicus*, adults and copepodid stages; *Oithona similis*, adults, the females without ovisacs; *Paracalanus parvus*, adults and copepodid stages.

DAVIS STRAIT. 70° North. Surface tow, 10 P.M., in floating ice. September 8, 1935. *Calanus hyperboreus*, adults, the only tow containing them in abundance; *Halithalestris croni*, two adults; *Oithona similis*, adults, a few females with ovisacs; *Paracalanus parvus*, adults; *Pseudocalanus elongatus*, adults.

DISKO ISLAND, GREENLAND COAST. 69° 20′ North. Surface tow taken at 10 A.M. July 17, 1935. *Acartia clausii, A. longiremis, Calanus finmarchicus, Halithalestris croni, Paracalanus parvus, Pseudocalanus elongatus.*

COBOURG ISLAND, OF ENTRANCE TO JONES SOUND, SOUTH OF ELLESMERE LAND. 75° 40′ North. Surface tow 2:30 A.M. September 4, 1935. *Calanus*

finmarchicus, Halithalestris croni, Oithona similis, Paracalanus parvus, Pseudocalanus elongatus. A few nauplii.

CAPE YORK AND MELVILLE BAY, GREENLAND COAST. 75° North. Surface and vertical hauls during the daytime. July 18–21, 1926; August 4–6, 1932; July 22, 1935. *Calanus finmarchicus, C. hyperboreus, Ectinosoma curticorne, Metridia longa, M. lucens, Oithona brevicornis, Paracalanus parvus, Pseudocalanus elongatus, Temora longicornis.*

HERBERT ISLAND, INGLEFIELD BAY. 77° North. Surface and vertical hauls during the daytime. July 25, 1926; July 25, 1935. *Augaptilus glacialis, Calanus finmarchicus, C. hyperboreus, Ectinosoma curticorne, E. neglectum, Metridia longa, Oithona similis, Parathalestris jacksoni, Pseudocalanus elongatus, Tegastes falcatus, Thalestris gibba, Tisbe furcata, Zaus aurelii, Z. goodsiri, Z. spinatus.* Development stages of crabs and copepods.

MURCHISON SOUND AND WHALE SOUND. 77° North. Dredge tow at bottom and net tow at surface. August 17–21, 1926; July 25, 1935. *Calanus finmarchicus, Dermatomyzon nigripes, Diosaccus tenuicornis, Harpacticus chelifer, Oithona similis, Parathalestris jacksoni, Paracalanus parvus, Pseudocalanus elongatus, Tisbe furcata.*

NORTHUMBERLAND ISLAND. 78° North. Dredge tow at bottom. August 16–17, 1926; July 30, 1935. *Alteutha depressa, Amphiascus minutus, A. nasutus, Bradypontius magniceps, Calanus finmarchicus, C. hyperboreus, C. tonsus, Cyclopina schneideri, Dactylopusia signata, D. vulgaris, Danielssenia fusiformis, D. typica, Ectinosoma curticorne, E. neglectum, Halithalestris croni, Harpacticus superflexus, H. uniremis, Metridia longa, M. lucens, Parathalestris jacksoni, Pseudobradya minor, Pseudocalanus elongatus, Stenhelia aemula, Tachidius brevicornis, Tegastes falcatus, T. nanus, Tisbe furcata, Zaus aurelii, Z. goodsiri, Z. spinatus.*

SMITH SOUND, ELLESMERE LAND. 78°10′ North. Surface haul at 6:20 P.M. July 31, 1935. *Calanus finmarchicus, Oithona similis, Paracalnus parvus, Pseudocalanus elongatus.* Development stages, especially of *Oithona.*

EASTERN COAST OF GREENLAND

ANGMAGSSALIK, 66° North. Dredge tow at the bottom. August 30, 1930; August 28, 1931. *Calanus finmarchicus, Herpyllobius arcticus, Microsetella norvegica, Paracalanus parvus, Pseudocalanus elongatus, Tisbe furcata.*

OFF CAPE SIMPSON. 73° North. Surface tow amid pack ice. August 13, 1930. *Calanus finmarchicus, C. hyperboreus, Pseudocalanus elongatus.* Development stages of copepods, crabs, and Euphausiids.

PENDULUM ISLAND. 74° North. Dredge tow at the bottom. July 20 and 30, 1930. *Augaptilus glacialis, Cyclopina schneideri, Diosaccus tenuicornis, Ectinosoma curticorne, E. neglectum, Laophonte elongata, Mormonilla polaris, Parartotrogus arcticus, Parathalestris jacksoni, Pseudobradya minor, Pseudomolgus groenlandicus, Scolecithrix brevicornis, Temorites brevis, Tisbe furcata, Undinella oblonga, Zaus goodsiri, Z. spinatus.*

BETWEEN CAPE BISMARCK AND THE NORTHWEST SIDE OF KOLDEWAY ISLAND. 76° North. Temperature of water 34°F. July 28, 1930. *Calanus finmarchicus,* few adults, but numerous development stages, together with those of crabs and Euphausiids.

NOTES ON THE CALANOIDA

Acartia clausii and **A. longiremis.** These two species are cosmopolitan in distribution and both have been reported from the Hudson Bay plankton by Willey. The males are better differentiated than the females and both sexes were found as far north as the 70th parallel.

Augaptilus glacialis G. O. Sars. This is the only polar representative of the genus and was first obtained during the Norwegian North Polar Expedition. It has since been found much farther south and thus is not exclusively arctic in its distribution. The new localities here given carry it far to the west and suggest that it may be circumpolar.

Calanus finmarchicus (Gunner). Present at almost every locality visited, but nowhere in any abundance except at Inglefield Bay. It was usually found in company with one or both of the other species of the genus, and development stages, probably including all three species, were abundant in the surface tows.

Calanus hyperboreus Krøyer. This large arctic form was also widely distributed but even less abundant than the preceding. The Davis Strait tow from 70° North was the only one containing more than one or two specimens.

Calanus tonsus Brady. This species lacks the serrated inner margins of the basipods of the fifth legs and the genital segment of the female is considerably swollen. This is probably the first record within the arctic circle and the number of specimens is very small.

Metridia longa Lubbock. A hardy arctic species but nowhere found in any abundance, although Nordenskiold has claimed that it is able to live in immense numbers in water-drenched snow at a temperature below Zero C.

Metridia lucens Boeck. Sars reported this species from within the Arctic Circle on the west coast of Norway, but added that he had never found it in other samples from the Arctic Ocean. The present records from Baffin Bay enable us to regard the species as an arctic form.

Mormonilla polaris G. O. Sars. Found only at Pendulum Island on the east coast of Greenland and obtained by Sars in the Norwegian North Polar Expedition as far north as the 81st parallel of latitude.

Paracalanus parvus (Claus). This is another common species very widely distributed here in the north and sometimes occurring in large numbers. It may be distinctly southern in its range, as reported by Sars, but it is evidently not prevented by the cold from breeding also in the Arctic Ocean.

Pseudocalanus elongatus (Boeck). Very widely distributed throughout the entire area and often the most numerous single species obtained. It was somewhat more abundant in shallower water than in deeper water, and evidently descends to the very bottom. The new localities here added make it circumpolar in its distribution.

Pseudocyclops obtusatus Brady. In spite of its generic name this is a peculiar small calanid, readily recognized by the structure of the fifth legs in both sexes. It was obtained by Sars on the Norway coast nearly as far north as the single female found in the plankton from the Bay of Gods Mercy.

Scolecithrix brevicornis G. O. Sars. The specimens described by Sars were found north of the 81st parallel of Latitude and east of Franz-Josef Land. Capt. Bartlett's specimens came from Pendulum Island on the east coast of Greenland and a little farther south.

Temora longicornis G. O. Sars. Cleve has reported this species from the Atlantic Ocean as far north as the 72nd parallel of Latitude. With one exception the specimens of the present list all came from the Labrador coast considerably farther south.

Temora stylifera (Dana). This is primarily a tropical species, but has been reported by Giesbrecht as far north in the Atlantic Ocean as the 60th

parallel of latitude. The present specimens came from the Labrador coast considerably farther south than that parallel.

Temorites brevis G. O. Sars. This is a very small species originally obtained during the Norwegian North Polar Expedition considerably to the east of the present localities. Here it was found only at Pendulum Island on the east coast of Greenland.

Undinella oblonga G. O. Sars. This small copepod looks very similar to a cyclopid, but an examination of its appendages shows it to be a true Calanid. It has not thus far been found anywhere except in the Arctic Ocean.

Undinula darwini (Lubbock). This calanid is usually found much farther to the south, but two males were present in the plankton taken in the Bay of Gods Mercy on Southampton Island. The structure of the fifth legs of these males is so peculiar as to leave no doubt of their identity.

NOTES ON THE HARPACTICOIDA

As already stated many of the present specimens were taken in dredge hauls at or near the bottom. Since there are more Harpactids at that depth than other kinds of copepods it would be expected that the species of this suborder would outnumber those of any of the other groups. The following lists shows that this really happened, the number of Harpactids equalling that of all the other suborders combined.

Alteutha depressa Baird. This is not a true arctic species, but it is a hardy copepod and has been found by Sars about as far north on the western coast of Norway.

Ameira longipes Boeck. This copepod has been reported by Sars from the polar islands north of "Elsemer" (Ellesmere) Land, taken in the second "Fram" expedition. Thus far the species has been confined to polar seas. The present specimens came from the mouth of Frozen Strait.

Amphiascus minutus (Claus). Found only near Northumberland Island in Smith Sound in company with the following species. It has been reported by T. Scott from Franz-Josef Land at about the same latitude farther east.

Amphiascus nasutus (Boeck). Twice the size of the preceding species, in company with which it was found, and so readily separated by size alone. It is distinctly arctic in distribution but comes down into the temperate zone along the west coast of Norway.

Cletodes tenuipes T. Scott. This harpactid has been reported from Franz-Josef Land by Sars, but has not before been captured in American waters. In the present plankton it was confined to the single peculiar tow taken near the mouth of Fury and Hecla Strait.

Dactylopusia signata Willey. Found on the Labrador coast, in Fox Channel, and also at Northumberland Island, where it was in company with the following species. Willey's original specimens came from farther west and were captured in a net let down through the ice.

Dactylopusia vulgaris G. O. Sars. Found in company with the preceding and about the same size but easily distinguishable by the structure of the fifth legs in the female. This is one of the commonest harpactids and was found by Sars along the entire Norwegian coast, even those portions which lie in the Arctic Ocean.

Danielssenia fusiformis (Brady). Confined to the single locality of

Northumberland Island in shallow water. This is a temperate rather than an arctic species and is here reported from Greenland for the first time.

Danielssenia typica Boeck. Found in company with the preceding and also at the mouth of Frozen Strait, these being the first American localities. It has been reported from Nova Zembla and Franz-Josef Land farther east.

Diosaccus tenuicornis (Claus). A few specimens were taken between Greenland and Ellesmere Land. Although it is not an arctic species it has been found nearly as far north on the Norwegian coast.

Ectinosoma curticorne Boeck. Found in several of the present lists and has been reported from Spitzbergen by T. Scott. Its small size and very short first antennae, each with a dusky patch inside the basal segment, will serve as distinctive features.

Ectinosoma neglectum G. O. Sars. Found on the Labrador coast and at several of the Canadian localities both in Capt. Bartlett's plankton and in that obtained by the Canadian Arctic Expedition. It was also reported by Sars from the north coast of Norway and is probably circumpolar.

Halithalestris croni (Krøyer). This is one of the largest harpactids and may be recognized by its size and by the long divergent caudal rami. It is a pelagic species but drifts in with the currents into various bays and straits and has been reported before from the west Greenland coast by Walker and Miers.

Harpacticus chelifer (Müller). Found only on the Labrador coast and in Murchison Sound, but has been reported by Sars from Egedesminde on the west coast of Greenland and by T. Scott from Franz-Josef Land.

Harpacticus superflexus Willey. Northumberland Island in the strait between Greenland and Ellesmere Land furnished the only specimens of this species. It was originally obtained by the Canadian Arctic Expedition considerably farther west and nearly as far north.

Harpacticus uniremis Krøyer. Found in company with the preceding species and has been reported from Behring Sea by Poppe, from Spitzbergen by T. Scott and from the whole Norwegian coast by Sars. It may thus be considered as an arctic form, coming down at times into the temperate zone.

Laophonte elongata Boeck. Found in three of the four regions here listed and reported by T. Scott from Franz-Josef Land. It may be distinguished by the structure of the fifth legs and by the long parallel caudal rami.

Laophonte horrida Norman. Found only in Fox Channel in company with the preceding species but has been reported from both the eastern and western coasts of Greenland. When obtained the specimens are usually so densely covered with mud that the body spines are invisible. If the mud is washed away the spines will serve to identify the species.

Laophonte perplexa T. Scott. Originally obtained by Scott from Franz-Josef Land the species was subsequently reported by Sars from Norway. Its presence in the plankton from the Bay of Gods Mercy is the first record from American waters.

Mesochra pygmaea (Claus). This minute harpactid is a dwarf form whose body segments have the appearance of being telescoped together. It has been reported from Franz-Josef Land and from the polar islands north of Grinnel Land.

Microsetella norvegica Boeck. Found at only two of the present stations but given a wide distribution in the Arctic Ocean by Cleve and Sars. It is a very small species but often found in large numbers.

Parathalestris jacksoni (T. Scott). Found in the last three regions but not along the Labrador coast and reported by Sars from the northern coast of Norway and by T. Scott from Franz-Josef Land.

Pseudobradya minor (T. & A. Scott). Like the preceding species this is well distributed everywhere except on the Labrador coast, but only one or two specimens in any locality. It was obtained by the Canadian Arctic Expedition from Bernard Harbor, Northwest Territories far to the west.

Pseudobradya similis (T. Scott). Found only in the plankton from the mouth of Frozen Strait, almost up to the Arctic Circle, and originally obtained by Scott from Franz-Josef Land.

Pseudothalestris pygmaea (T. Scott). This is another of the dwarf species whose body segments appear to be telescoped together, giving it a peculiar stunted appearance. It was found only at the mouth of Frozen Strait.

Rhynchothalestris helgolandica (Claus). This was originally obtained by Claus from Helgoland, but has been reported from Greenland by Stephensen and from various localities in the Arctic Ocean. It was here confined to the plankton from the mouth of Frozen Strait.

Robertsonia tenuis Brady. Only a few specimens of this species were found in the second group of localities, but it has been obtained by Scott from Spitzbergen and Franz-Josef Land, and from Greenland by Wesenberg-Lund.

Stenhelia aemula (T. Scott). A few specimens were found at Northumberland Island and this is the first record of the species in polar regions.

Tachidius brevicornis Lilljeborg. Another species captured only at Northumberland Island in the bottom dredge. It is a widely distributed species chiefly confined to temperate localities but taken by the Canadian Arctic Expedition well within the Arctic Circle.

Tegastes falcatus Norman. Also taken in the bottom dredge at Northumberland Island, it has been reported by T. Scott from Nova Zembla and Franz-Josef Land. It has also been found around the British Isles and near Ceylon and hence is not confined to arctic seas.

Tegastes nanus G. O. Sars. This was found in company with the preceding species and is even smaller in size. It has previously been reported only from the Norwegian coast by Sars, at about 63° North Latitude.

Thalestris gibba (Krøyer). Two specimens were obtained from Fox Channel and three from Inglefield Bay; it has also been recorded by Scott from Franz-Josef Land and by Sars from the north coast of Finland.

Tisbe finmarchica (G. O. Sars). Sars reported this as a true arctic species from the northern coast of Finmark and the polar islands north of Grinnell Land. In the present lists the species is confined to two specimens from the peculiar plankton taken at Fury and Hecla Strait.

Tisbe gracilis (T. Scott). This species is confined to the plankton from the Bay of Gods Mercy. It was originally found on the Scottish coast, but was reported by Sars from the Finmark coast and the west coast of Norway as far north as the present locality.

Tisbe minor (T. Scott). Found in the present plankton only at the mouth of Frozen Strait, but reported by Scott from Franz-Josef Land, and by Sars from the west coast of Norway as far north as Frozen Strait.

Tisbe furcata (Baird). Found at a majority of the localities here listed, often in considerable numbers, and recorded as widely distributed throughout the Arctic Ocean.

Zaus abbreviatus G. O. Sars. This is the smallest species of the genus,

and has been found on the west coast of Norway and north of Grinnell Land. Its appearance at two of the present localities is new to American waters.

Zaus aurelii Poppe. Found at Northumberland Island, and recorded by Scott from the northern coast of Finmark. This is one of the larger species and has a very small rostrum and a very narrow urosome.

Zaus goodsiri Brady. Found on both the east and west coasts of Greenland and recorded from Spitzbergen by Scott and from the polar islands north of Grinnell Land by Sars. It is half as large again as the preceding form and shows a huge angular rostrum.

Zaus spinatus Goodsir. Found in many of the present localities except those along the Labrador coast, and reported to be widely distributed in the arctic zone. This is the smallest of the four species and only two-fifths the size of *goodsiri,* with a slightly prominent semicircular rostrum.

Zosime typica Boeck. This species was confined to the plankton from the Bay of Gods Mercy, its first appearance in American waters, but it has been recorded by Scott from Franz-Josef Land and Nova Zembla.

NOTES ON THE CYCLOPOIDA

Some of the cyclopids here listed probably live semiparasitically upon or within the bodies of other marine animals. But having been captured while swimming freely there is nothing to connect them with any host. Some of them, however, appeared in the plankton taken by the Danish Ingolf Expedition, and in the account of that expedition were assigned by Hansen to definite hosts.

Arctopontius expansus G. O. Sars. Occurring in these lists only in Fox Channel, it was obtained by the Ingolf Expedition in Davis Strait, and is probably more or less well distributed in this region. Neither in the Ingolf material nor in that examined by Sars was any host discovered.

Artotrogus orbicularis Boeck. Found only in Fox channel; Boeck's original specimen came from the south coast of Norway, where other specimens were later found by M. Sars. It has also been reported from the Kara Sea by Hansen, and in all three instances was taken from nudibranch mollusks.

Ascomyzon intermedium Hansen. Found only in Fox Channel, but was also obtained by the Ingolf Expedition from Davis Strait, where it was dredged at a depth of 582 fathoms. All the specimens thus far obtained have been females with no hint of their host.

Bradypontius caudatus G. O. Sars. Associated with the preceding species in Fox Channel, but not obtained by the Ingolf Expedition. Sars stated that it was the largest siphonostomous cyclopid (2.90 mm. long) with which he was acquainted and nothing is known of its host.

Bradypontius groenlandicus Hansen. A second species of the same genus from Fox Channel and reported by the Ingolf Expedition from Davis Strait. Hansen's material included both sexes but the present specimens were all females, with nothing to suggest their host.

Bradypontius magniceps (Brady). A third species of the genus from Fox Channel, not obtained by the Ingolf Expedition but reported by Sars from western Finmark a little farther north, without data as to the host.

Cyclopina schneideri T. Scott. Found at several localities in Fox Channel and on both coasts of Greenland and recorded by Scott from Spitz-

bergen and Franz-Josef Land and from the Norwegian coast by Sars. This is very likely a free swimming form and not semiparasitic.

Corycaeus anglicus Lubbock. Sars has designated this as a pronouncedly pelagic species which is occasionally swept into the Norwegian fjords and similar locations by strong currents. It has not been reported previously from any American locality.

Dermatomyzon nigripes (Brady). Found in Fox Channel and Murchison Sound and reported by Scott from Spitzbergen and Franz-Josef Land. It is not, however, exclusively arctic but is also found in the temperate zone.

Dyspontius striatus Thorell. Found only in Fox Channel but reported by Sars from the Finmark coast considerably farther north. It is also widely distributed in the temperate zone and is even found in the Bay of Naples. Sars regarded this species as in all probability free swimming.

Farranula carinata (Giesbrecht), and **F. rostrata** (Claus). These minute cyclopids seem out of place in plankton from so far north, but their identification is easy and certain. They were present on the coast of Labrador, in the Bay of Gods Mercy and at Fury and Hecla Strait.

Hemicyclops purpureus Boeck. Found in Fox Channel which is a little farther north than previous records of the species. When alive the oviducts and ovisacs are bright red in color and this is not wholly lost in formalin.

Lichomolgus agilis (Leydig). Found in Fox Channel and reported by Scott from the British Isles and by Sars from the Norway coast. Sars was able to determine that the Norway specimens were parasitic upon nudibranch mollusks.

Myzopontius pungens Giesbrecht. Found only in Fox Channel and reported by Scott from Franz-Josef Land and by Sars from the Norway coast although Giesbrecht's types came from the Bay of Naples.

Oithona similis Claus. Found in most of the localities here listed and very widely distributed in all oceans and zones. To judge from the larvae found in the surface tows it breeds extensively in these northern latitudes.

Oithona spinirostris Claus. Common along the Norwegian coast as far north as the present localities, but has not before been reported from any American plankton. Usually found in company with the preceding species.

Oithonina nana Giesbrecht. Found in company with the preceding along the southern portion of the Labrador coast, and this record is apparently a little farther north than any previous American report.

Oncaea borealis G. O. Sars. Found at the Bay of Gods Mercy and in Fox Channel and reported from the Norway coast and the Polar Sea. It is somewhat more strictly an arctic form and not found much farther south.

Oncaea venusta Philippi. This is another southern form found on the coast of Labrador and in the Bay of Gods Mercy. It is very widely distributed in temperate and tropical localities but this is the farthest north that it has been recorded.

Parartotrogus arcticus T. Scott. Found in Fox Channel and at Pendulum Island and has been reported from Spitzbergen and Nova Zembla by Scott, and from the east coast of Greenland by Hansen.

Pseudomolgus groenlandicus Hansen. Found only at Pendulum Island on the east coast of Greendland but reported by Hansen to occur also on the west coast along the shore of Baffin Bay.

NOTES ON THE NOTODELPHYOIDA

Botryllophilus inaequipes Hansen. A single female was taken in Fox Channel while Hansen's types were obtained from Davis Strait. It will probably be found in other localities upon further investigation.

Doropygelia thorellii Aurivillius. Found only in Fox Channel but taken by the Ingolf Expedition from Davis Strait and by Schmidt from southeast of Iceland. It is found in the branchial cavity of ascidians.

Herpyllobius arcticus Steenstrup & Lütken. A single female was found on the annelid, *Harmothoë imbricata,* on the east coast of Greenland. The Ingolf Expedition reported the species from Davis Strait and the west coast, all the annelid hosts belonging to the genus *Harmothoë.*

ICHTHYOLOGY.—*A new polynemid fish collected in the Sadong River, Sarawak, by Dr. William T. Hornaday, with notes on the genera of* Polynemidae.[1] George S. Myers, United States National Museum. (Communicated by A. Wetmore.)

Fifty-nine years ago, William T. Hornaday, now the honored director-emeritus of the New York Zoological Park, travelled in India, the Malay Peninsula, and Borneo to collect natural history specimens for Ward's Natural Science Establishment of Rochester. His book dealing with that trip, *Two Years in the Jungle* (New York, 1885), is now one of the classics of zoological exploration in Asia. The fishes collected by Dr. Hornaday became the property of the United States National Museum, in which institution he remained for several years as chief taxidermist. Some of the fishes were identified by Dr. Tarleton Bean and the rest have recently been determined by the present writer. One species, a remarkable *Polynemus,* appears to be unnamed more than half a century after its collection.

Polynemus hornadayi, n. sp.

Holotype.—U.S.N.M. 100632, a specimen 195 mm standard length and 260 mm including caudal fin, obtained by W. T. Hornaday on October 2, 1877, while fishing with poison, in the Ensengi River, a large creek emptying into the Sadong River from the west about six miles below Simujan, southwestern Sarawak, Borneo. Dr. Hornaday described the Ensengi as a stream 40 feet wide and 8 to 10 feet deep, with murky water and swift current. The holotype is the identical specimen illustrated on the plate facing page 386 of *Two Years in the Jungle,* from a pen and ink drawing of the late Dr. Frederic A. Lucas. The figure is reproduced here.

Paratypes.—U.S.N.M. 35719, ten smaller specimens, obtained at the same place and on the same date. One of these is now in the British Museum.

Diagnosis.—A species of *Polynemus* allied to *P. hilleri* Fowler, *P. paradiseus* Linnaeus, and *P. dubius* Bleeker in the presence of but seven dorsal spines, but differing in the very tiny scales, 94 to 97 in the lateral line to caudal base and 31 to 35 in transverse series from origin of first dorsal to pelvic origin.

Description.—Dorsal VII–I, 15½. Anal II—11½. Pectorals 16 to 18, with 7 filaments. Pelvics I–5. Lateral line scales with pores, from upper end of gill opening to end of hypural fan, 94 to 97. Transverse scales from origin of first dorsal to pelvic base 8 to 9/1/21 to 25. Gill rakers fairly long, 12 on upper and 15 on lower limb of first arch.

[1] Published by permission Secretary, Smithsonian Institution. Received April 17, 1936.

Greatest depth approximately equal to head length, 4.8 in standard length. Eyes minute, 9.5 in head length, 2.9 to 3.1 in the convex interorbital space, approximately 2 in snout, and nearly 7 in postorbital part of head. Mouth rather large, reaching far behind eye. Maxillaries scaly, 1.8 in head. Upper jaw not emarginate at symphysis. Anterior and posterior nostrils close together, immediately in front of eye. Preopercular edge finely denticulated for some distance above its rounded posterior angle. Upper lip scarcely evident; lower well developed, but interrupted at symphysis. A narrow band of extremely fine, villiform teeth, narrowly interrupted at the symphysis, in each jaw; the band is wider towards the front but the teeth do not extend to the outside of the jaws. Vomer with a narrow, transverse, crescentic (or angled) patch of similar teeth. An oblong patch, rounded in front and acu-

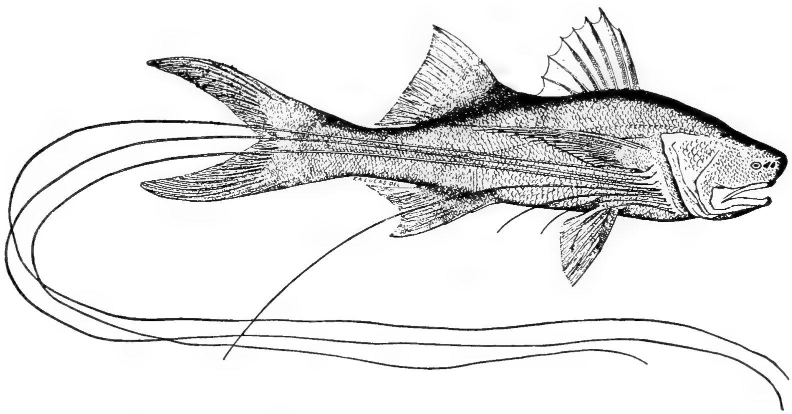

Fig. 1.—*Polynemus hornadayi*, new species. Holotype. After Hornaday, from a drawing by the late Dr. Frederic A. Lucas. Reproduced by permission of Charles Scribner's Sons, New York.

minate behind, of similar teeth on each palatine, and a very small, narrow patch on each pterygoid.

Origin of first dorsal very slightly behind that of pectorals. Spines of first dorsal slender and somewhat flexible, the first one nearly three fourths as long as the second. Second spine longest, a little shorter than head, minus snout. Origin of second dorsal slightly in advance of that of anal. Soft dorsal, anal, and caudal densely and finely scaled for more than half their lengths. A few rows of fine scales along and behind each spine of first dorsal, and along pelvic spine. Caudal long and very deeply forked, with pointed lobes. Pectoral fin pointed, straight, the upper part of its base above mid-line of body depth, its rays all simple; the fin is approximately 1.5 times as long as head and reaches the posterior third of the soft dorsal base. The two upper pectoral filaments exceed the caudal tip by more than one and two-thirds the *total* length of the fish (from snout tip to caudal tip). The length of the longest (upper) filament on the holotype is equal to more than 2.5 the total length of the fish including caudal. The third filament is nearly as long as the first two, the fourth nearly reaches to caudal tip, the fifth to the anal origin, the sixth to vent, and the seventh to beyond middle of the appressed pelvics. Pelvic fins longer than postorbital part of head. Distance between origins of anal and pelvic fins approximately equal to head length. Vent far in advance of anal fin, between tips of appressed pelvic fins. Air-bladder absent.

Color of alcohol specimens dirty brownish. No black marks visible on pectorals.

Measurements.—Measurements in millimeters of four specimens are given. These are taken from point to point, as indicated, with dividers, not reduced to ideal axial measurements. Under each category the first measurement refers to the holotype, the second to the British Museum paratype, and the third and fourth to two other paratypes.

Standard length 195, 142, 141, 44. Depth at first dorsal origin 53, 34, 35, 26.5. Head length (minus opercular membrane) 53, 37, 36, 28.5. Maxillary length (snout tip to its end) 28, 22, 20, 16. Snout (middle of tip to eye) 12, 7, 8.5, 7. Eye diameter (horizontal) 5.5, 4, 3.5, 3. Interorbital (between fleshy orbital rims) 16, 12, 12, 9.5. Postorbital 38, 28, 24.5, 19.5. Width end maxillary 9, 6, 6.5, 4. Predorsal (snout tip to origin first dorsal) 67, 46, 48, 36. Snout tip to second dorsal origin 113, 82, 83, 63. Least depth caudal peduncle 21, 15, 14.5, 11. Length caudal peduncle (base of last anal ray to middle of end of hypural joint) 46.5, 37, 37, 26. Pelvic origin to anal origin 58, 42, 38, 27.5. Length second spine of first dorsal 35.5, 25.5, 27, broken in smallest example. Length spine of soft dorsal 12.5, 10, 11.5, 9. Length second anal spine 13, 14, 13, 7.5. Length pectoral fin 85, 58.5, 58, 48.5. Length first free pectoral filament of holotype 670 (filaments broken in most of other specimens).

The relationships of *P. hornadayi* are discussed below, under the genus *Polynemus.*

NOTES ON THE GENERA OF POLYNEMIDAE[2]

In attempting to place the new species described above, I have encountered considerable confusion in the generic classification of this family. After examining the material in the National Museum, I have prepared the following synopsis of the genera, which, while merely tentative, seems to express the general phylogenetic lines in the family better than most systems. The last general review of Polynemid genera was given by Gill (Proc. Acad. Nat. Sci. Philadelphia, 1861, pp. 271–282) and since his revision there has been little improvement in the system and few new characters have been brought forward.

Although the time is not ripe for an exhaustive discussion of the phylogeny of the genera, it appears to me that *Polydactylus* contains the most generalized species, and all of the other genera are more or less direct derivatives of *Polydactylus*-like ancestors. *Eleutheronema* has specialized in the dentition and the elongate, regular body form. *Filimanus* has developed a peculiar physiognomy, long filaments, and a very compressed form, while it has lost the pectoral fold. *Pentanemus* has something of the appearance of *Filimanus*, but has developed a very long anal. *Galeoides* is much like the *plebejus* type of *Polydactylus* but it has a narrow maxillary and has developed numer-

[2] It should be noted that in the case of Polynemids with very long filaments, such as *Pentanemus* and *Polynemus*, the filaments are brittle and easily broken when the specimens were originally preserved in alcohol. Specimens originally fixed in formalin have the filaments pliable and tough, and not easily broken.

ous filaments extending far forward, with a long pectoral fold to cover them. *Polynemus* is a very distinct branch, which has a specialized shoulder girdle architecture, very long filaments, loss of air-bladder, a slender peduncle, long caudal, sharp head, and small scales. It, too, has lost the pectoral fold in changing the position of the girdle elements. *Polistonemus* is purely an offshoot of *Polynemus*, differing only in the much greater number of filaments. If intermediate species are found, it should not be recognized as a distinct genus.

Synopsis of the Genera

1a. Anal fin approximately twice as long as soft dorsal fin, and its origin more anterior than that of the latter; preopercular edge entire; pectoral fin inserted rather high, without a fleshy fold extending from the lower part of its base to cover the bases of one or more of the pectoral filaments; maxillary widened behind, the mouth rather oblique and the snout projecting very little beyond it; pectoral rays all simple; pectoral filaments very long, 5 in number; teeth not extending to outer part of jaws. *Pentanemus* Günther.

1b. Anal fin of approximately the same length as soft dorsal fin, or shorter; preopercular edge more or less denticulated.

2a. Pectoral fin inserted low, the upper part of its base much below mid-line of body; lateral line straight or with a faint curve anteriorly.

3a. No sharp fold of skin extending from lower part of base of pectoral fin to cover the bases of one or more of the pectoral filaments; maxillary very wide at end; mouth very oblique; snout squarish and very blunt and projecting little or not at all beyond mouth; scales large; pectoral filaments 7 in number, very long; lateral line angled, with the forward part high though but little curved. *Filimanus*, new genus.

3b. A sharp fold of skin projecting downward or forward from lower end of base of pectoral fin and covering the bases of one or more of the pectoral filaments; mouth chiefly horizontal; snout projecting considerably beyond mouth; pectoral filaments rather short; lateral line nearly straight.

4a. Lower lip absent except towards rictus, the teeth extending on the exterior part of the jaws; elongate, small-scaled species with a very large mouth, long maxillary, and only 3 or 4 pectoral filaments. *Eleutheronema* Bleeker.

4b. Lower lip extending far forward and no teeth on outside of jaws.

5a. Maxillary distinctly widened at its end; pectoral fold little developed. *Polydactylus* Lacépède.

5b. Maxillary scarcely widened at its end; pectoral fold very well developed, covering the bases of most of the 9 or 10 pectoral filaments. *Galeoides* Günther.

2b. Pectoral fin inserted high, the upper part of its base at mid-depth of body, or higher, without a sharp pectoral fold extending down from lower part of pectoral base to cover the bases of one or more of the pectoral filaments; base of upper pectoral filament inserted higher than lowest ray of pectoral fin; lateral line with its anterior part rising in a long, low curve; caudal peduncle elongate; head small; pectoral filaments very long; maxillary widened behind; no air-bladder.

6a. Seven pectoral filaments. *Polynemus* Linnaeus.

6b. Fourteen pectoral filaments. *Polistonemus* Gill.

Pentanemus Günther

Pentanemus (Artedi) Günther, Cat. Fish. Brit. Mus., **2:** 331. 1860 (type by monotypy *Polynemus quinquarius* Linnaeus).

A single species of this genus. *Pentanemus quinquarius* (Linnaeus), from West Africa, is known. I have not seen specimens, but have derived my data from Boulenger's excellent figure and description (Cat. Freshwater Fishes Africa, **4:** 100. 1916. fig. 61).

Filimanus, n. g.

This new genus is based upon a single species, the genotype, *Polynemus melanochir* Cuvier and Valenciennes (Hist. Nat. Poiss., **7:** 513. 1831), from the Malay Archipelago. I have examined only a single specimen of *Filimanus melanochir*, from Java. (U.S.N.M. 72742).

Eleutheronema Bleeker

Eleutheronema Bleeker, Versl. Akad. Amsterdam, **14:** 110. 1862 (type by monotypy *Polynemus tetradactylus* "C.V." = *P. tetradactylus* Shaw); Bleeker, Versl. Akad. Amsterdam, vol. 14, 1862, p. 123 (description, with inclusion of two species, *P. tetradactylus* and *P. tridactylus* Bleeker).

In the first citation of Bleeker given above he merely lists "*Eleutheronema tetradactylus* Blkr. = *Polynemus tetradactylus* C. V." Since the mere citation, prior to January 1, 1931, of a recognizable, previously described species in conjunction with a new generic name is sufficient under the International Rules (Article 25), this reference validates the generic name *Eleutheronema.* He mentions only one species, *tetradactylus* of Cuvier and Valenciennes, which *ipso facto* becomes the genotype.

Only two species of *Eleutheronema* are currently recognized, *E. tetradactylum,* with four pectoral filaments, ranging from India to Northwestern Australia, and *E. tridactylum,* with three pectoral filaments, from the Malay Peninsula and Archipelago. Of the former, I have examined three specimens in the National Museum, from Rangoon (44726), Java (72740), and Formosa (85481). Of the latter species, I have studied one example (72737) from Java.

Polydactylus Lacépède

Polydactylus Lacépède, Hist. Nat. Poiss., **5:** 419. 1803 (type by monotypy *Polydactylus plumierii* Lacépède = *Polynemus virginicus* Linnaeus).

Trichidion (Klein) Gill, Proc. Acad. Nat. Sci., Philadelphia, 1861, p. 274 (type by original designation *Polynemus plumierii* Lacépède = *Polynemus virginicus* Linnaeus).

Klein's name *Trichidion* was originally published in 1749. It is thus pre-Linnaean and can not be accepted. Walbaum, in 1792 (Artedi Gen. Pisc., pt. 3, p. 585), republished Klein's *Trichidion* but the International Commission on Zoological Nomenclature, in Opinion 21, has declared these reprinted names of Klein to be unavailable under the Code.

This large genus is, as I define it, a very heterogeneous assemblage, but the species all seem to be more similar to each other than to any members of other genera. The range is practically co-extensive with that of the family. Very likely a careful study of adequate material will show a need for breaking it up into several more well knit groups. For example, *Polydactylus quadrifilis* is very different in appearance from the ordinary types such as *virginicus*, *approximans*, and *plebejus*.

I have examined a number of species in the National Museum, including *P. virginicus* (64063), *P. octonemus* (48883), *P. opercularis* (41054), *P. approximans* (65621), *P. sexfilis* (55555; 65990), *P. indicus* (76627), *P. plebejus* (58048), and *P. heptadactylus* (72741).

GALEOIDES Günther

Galeoides Günther, Cat. Fish. Brit. Mus., **2**: 332. 1860 (type by monotypy *Polynemus polydactylus* Vahl = *Polynemus decadactylus* Bloch).

This genus contains two species. Of the West African *Galeoides decadactylus* I have examined several specimens from Sierra Leone and Ashantee (U.S.N.M. 42196; 42213). Steindachner, in his Ichthyologische Notizen, No. 8 (Sitzb. Ak. Wien, **60** (1): 137. 1870), has described *Galeoides microps* from China. I have not seen this fish and I find no reference to any examples obtained since the original description.

POLYNEMUS Linnaeus

Polynemus Linnaeus, Syst. Nat., ed. 10, 1758, p. 317 (type as fixed by the International Commission on Zoological Nomenclature, under suspension of the Rules, Opinion 93, 1926, *Polynemus paradiseus* Linnaeus).

The confusion that has reigned in regard to the application of the generic name *Polynemus* has happily been settled (whether on adequate premises or not I do not attempt to say) by the International Commission in Opinion 93 (Smithsonian Misc. Coll., **73**: 5–10. 1926.)

In Weber and de Beaufort's useful synopsis of the Indo-Australian Polynemids (Fishes of the Indo-Australian Archipelago, **4**: 196–218. 1922), the generic affinities of several of the species, according to the system proposed here, is not evident. In their key to the species of "*Polynemus*" (pp. 201–202) it would seem that all of the species in sections 1 and 2 belong to *Polydactylus*, in addition to *heptadactylus* in section 3. *Polynemus melanochir* is referred above to a new genus, *Filimanus*. *Polynemus longipectoralis*, *P. dubius*, and *P. borneensis* (from which *Trichidion hilleri* of Fowler is distinct) certainly are congeneric with the Indian *P. paradiseus*. *Polynemus macrophthalmus* also probably belongs to this genus. Including *hilleri* and *hornadayi* there seem, then, to be only seven species certainly referable to *Polynemus*. I have seen specimens of none of them save *hornadayi*, but in order to indicate the characters of the new form I have compiled the following key. My data for *paradiseus* is from Day (Fishes of India, p. 176, pl. 42, fig. 4).

Synopsis of the Species

1a. Dorsal spines 7, the first more than half as long as the second, which is the longest.

2a. Scales 94 to 97; pectoral fin plain, reaching last third of soft dorsal base; upper pectoral filaments more than twice as long as body and caudal fin; snout blunt and broad; eye 9.5 in head, about 3 in interorbital. (Sadong R., Borneo). *P. hornadayi* Myers.

2b. Scales 65 to 70 (or slightly more?).

3a. Pectoral fin with most of its terminal portion black; upper pectoral filaments only slightly longer than body and caudal fin. (Baram R., Borneo.) *P. hilleri* (Fowler).

3b. Pectoral fin plain; pectoral filaments exceeding tip of caudal by nearly the length of head and body.

4a. Eye diameter about 3 in interorbital; pectoral fin with 15 rays; upper lobe of caudal longer than lower; scales about 70. (Bay of Bengal and coast of Burma). *P. paradiseus* Linnaeus.

4b. Eye 1.8 in interorbital; pectoral fin with 17 rays; caudal lobes equal; scales 65 to 70. (Sumatra, Borneo, and Siam). *P. dubius* Bleeker.

1b. Dorsal spines 8, the first minute, the third one longest.

5a. Pectoral fins about as long as head without snout; eye large, 4.5 to 6 in head; distance between origins of pelvics and anal less than length of head; scales 88 to 93; anal spines 3. (Sumatra and Borneo.) *P. macrophthalmus* Bleeker.

5b. Pectorals longer than head; eye small, 5.5 to 7 or more in head; distance between origins of pelvics and anal more than length of head.

6a. Scales 84 to 87; anal spines 2. (Banjermassin, Borneo.) *P. longipectoralis* Web. & de Bfrt.

6b. Scales 65 to 66; anal spines 3. (Sumatra and Borneo.) *P. borneensis* Bleeker.

POLISTONEMUS Gill

Polistonemus Gill, Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 277 (type by original designation *Polynemus multifilis* Schlegel).

This genus is in all respects a *Polynemus* excepting for the increased number of pectoral filaments. I have examined two fine examples of *Polistonemus multifilis* (U.S.N.M. 53409; 53410) collected in the Kapoeas River, Borneo, by Dr. W. L. Abbott. This is the only known species.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

531ST MEETING

The 531st meeting was held in the Assembly Hall of the Cosmos Club, November 13, 1935, President W. T. SCHALLER presiding.

Informal communications.—ANNA I. JONAS presented new evidence for the age of the limestones of Frederick Valley, Maryland. She stated that the valley contains on its borders blue slaty limestone, called Frederick limestone, and in the center of the syncline purer, more massive, Grove limestone. Study of the fossils from these limestones has shown the Frederick limestone is Upper Cambrian in age, the Lower Ozarkian of Ulrich. This conclusion is based on the determination of brachiopods and trilobites by Cooper, Raymond, and Bridge. The overlying Grove limestone, on the basis of its fossils, cephalopods and brachiopods, as determined by Foerste and Cooper, is of Upper Ozarkian age comparable to the Chepultepec of Tennessee and Gasconade of Missouri. There is no Canadian or Middle Ordovician in the valley as was thought by Bassler. The Conestoga limestone of Pennsylvania is similar to the limestones of Frederick Valley in lithology. Both the Conestoga and Frederick limestone unconformably overlie Lower and Middle Cambrian formations. Brachiopods believed to be from the Conestoga limestone were previously called Chazyan in age and considered the same as those from the Frederick limestone. These brachiopods have been recently determined by Cooper and Resser to be *Nisusia festinata*, characteristic of the Lower Cambrian Kinzers formation. The quarry from which the brachiopods were obtained is on the south face of a hill of Kinzers shale. At present no fossils except crinoid stems have been found in the Conestoga and it may be Upper Cambrian or lowest Ordovician in age. (*Author's abstract.*)

Program.—M. R. CAMPBELL: *The origin of the material forming the alluvial fan of Potomac river.* Discussed by Mr. STOSE.

ERNST CLOOS and H. GARLAND HERSHEY, Johns Hopkins University: *Structural age determination of Piedmont granites in Maryland.* A direct age determination of Piedmont intrusives is not possible where they are separated from known Paleozoic sediments by a wide belt of metamorphics of disputed age. Therefore, structures which are recognizable over a large area were used. Flow cleavage and fracture cleavage are Paleozoic (post-Conestoga) structures that can be recognized everywhere in the Piedmont from Maine to Alabama. The Maryland intrusives—Port Deposit Granite Gneiss and Baltimore Gabbro—follow, transgress, and engulf these structures and destroy them by recrystallization through metamorphism. The writers suggest that these intrusives are Paleozoic and not pre-Cambrian as previously assumed. Flow cleavage and fracture cleavage may be useful tools in other portions of the Piedmont, and it may be necessary to change the age determinations of other intrusives. (*Authors' abstract.*) Discussed by MR. STOSE and Miss JONAS.

532ND MEETING

The 532nd meeting was held in the Assembly Hall of the Cosmos Club, November 27, 1935, President SCHALLER presiding.

Informal communications.—C. S. Howard showed graphs of suspended matter, sulphates, and total discharge of the Colorado river at Grand Canyon and at Willow Beach.

Program.—Taisia Stadnichenko: *Petrography and microstructure of coal.*

While the first microscopic examinations of coal were made by Witham and Hutton in England in 1833, the systematic studies attempting to correlate the observed structures with the physical characteristics and the chemical composition date back not more than twenty-five years. The voluminous literature on the "petrography" of coal deals mostly with the descriptions of the observed structures and gives some botanical and morphological interpretations. Comparatively few works are devoted to the broader aspects of the origin, composition, conditions of accumulation and the effects of local and regional metamorphism on the various plant components contributing to the coal bed.

At present several systems of nomenclature are in use and a number of terms are either synonymous or overlap one another.

Table 1.—Systems of Nomenclature

Common terms used for over a century	Fayal (1887)	Jeffrey (1915)	Stopes (1919) Expanded in 1932	Thiessen (1920) Expanded 1929
Bright	Houilles claires	Lignoid	Vitrain	Anthraxylon Attritus
Dull	Houilles foliares	Canneloid	Clarain	
Hard	Houilles ternes		Durain	Also splint, synonymous with durain
Mother of coal Mineral charcoal (or fusain in France)	Fusain		Fusain	

The significance of the new terms is often exaggerated, as little has been added to our knowledge of coal through the introduction of "clarain" or "attritus" in place of plant micro-debris, or "durain" in place of dull or hard coal—terms used for almost a century.

The improved technique in the preparation of thin sections and polished surfaces of coal and the examination of the columnar samples in addition to an increase in the definite knowledge of the plant components of a coal bed contributed also the better understanding of the various problems such as origin, conditions of accumulation, coking, characteristics of ash, washing of coal, and fractional separation of the various components of a coal bed. (*Author's abstract.*) Discussed by Mr. Schaller.

W. H. Bradley: *Faulting of unconsolidated beds.* Certain lithologic units of Upper Devonian age that crop out in western Steuben County, New York, show structural features indicating that the sea floor was warped and faulted during the depositional epoch. The warping is indicated most clearly by one sandstone unit 350 feet thick that changes rather abruptly into shale where it goes into certain synclines and back to sandstone again where it comes out

the other side and yet maintains a uniform thickness. Apparently the synclines where the shale accumulated sank enough during deposition to accommodate a thickness of mud that, when compacted, equaled the thickness of the sand deposited adjacent to the troughs in the same time interval.

The faults that occurred while the beds were still soft have throws ranging from a few feet to more than 100 feet. They are accompanied by bands of contorted, folded, and faulted beds of shale and fine grained sandstone that range in width from 100 yards to nearly two miles. The bands of deformed rocks are restricted vertically to a stratigraphic interval estimated to be 100 to 200 feet thick. Farthest away from a fault the beds in a deformed zone are gently folded but toward the fault the folding increases in intensity and culminates in a zone along the fault line where individual beds lose their identity by flowage and rupture. Layers of sand, clay, and coquina flowed together and commingled in a way that could only have happened when the material was nearly fluid. Layers of sand were plastically deformed and in the lower part of the deformed zones failed along the crests of sharp folds by microfaults. Microfaults in layers of unconsolidated sand apparently indicate that the deforming stress was applied rapidly.

Many features of these deformed zones resemble features produced in modern unconsolidated deposits by earthquakes. Hence, they are interpreted as the result of faults that tilted the sea floor and produced earthquakes. (*Author's abstract.*) Discussed by Messrs. RUBEY, MISER, and Miss JONAS.

PHILIP B. KING: *Permian of the Guadalupe mountains.* This paper describes the complex stratigraphic variations of a group of rocks of Permian age exposed in the Guadalupe Mountains, a range lying in western Texas near the New Mexico boundary. The rocks are wonderfully exposed in steep, bare escarpments and deep canyons. They are all of marine origin, and consist chiefly of various sorts of limestone and sandstone. Fossils occur in great numbers in certain beds. The stratigraphic variations consist of: 1. A prominent unconformity in the lower part of the sequence, by which over 1,000 feet of the sandstones of the lower part of the Delaware Mountain formation overlap northward against the uplifted surface of the preceding Bone Spring limestone. 2. Abrupt replacement northward of sandstones and thin-bedded limestones of the middle and upper part of the Delaware Mountain formation by massive limestones of the Dog Canyon and Capitan formations. 3. Replacement of the massive Capitan limestone still farther north by the thin-bedded Carlsbad limestone. The massive Capitan and Dog Canyon limestones are found to occupy northeast-trending belts a few miles in width, and they apparently stood as barriers between the unlike deposits of Carlsbad and Delaware Mountain type. These features are related to the margins of a subsiding area, the Delaware Basin, which existed in Permian time, and the massive limestones have many features in common with the modern barrier reefs. (*Author's abstract.*) Discussed by Messrs. R. C. WELLS, J. S. WILLIAMS, WOODRING, GILLULY, SEARS.

533RD MEETING

The 533rd meeting was held in the Assembly Hall of the Cosmos Club, December 11, 1935, President SCHALLER presiding.

By vote of the Society Mr. J. C. REED received a cash prize of ten dollars for the best presentation of a paper by a member during the past year. Messrs. TRASK, KNECHTEL, G. A. COOPER, BRADLEY, ANDREWS, and HEWETT were voted honorable mention.

Vice-President H. D. MISER took the chair during the presentation of Dr. Schaller's Presidential Address entitled: *A mineralogist ventures in geology.*

43RD ANNUAL MEETING

The 43rd Annual Meeting was held in the Assembly Hall of the Cosmos Club after the adjournment of the 533rd regular meeting, President W. T. SCHALLER presiding. The annual report of the Secretaries was read. The Treasurer then presented his annual report showing an excess of assets over liabilities of $1,158.18 on December 11, 1935. The Auditing Committee reported that the books of the Treasurer were correct.

The results of the balloting for officers for the ensuing year were as follows: *President,* M. I. GOLDMAN; *Vice-Presidents,* H. D. MISER and R. C. WELLS; *Treasurer,* A. H. KOSCHMANN; *Secretaries,* GEO. TUNELL and G. A. COOPER; *Members-at-large-of-the-Council,* C. L. GAZIN, J. F. SCHAIRER, F. C. CALKINS, C. F. PARK, and L. G. HENBEST; Nominee for *Vice-President of the Washington Academy of Sciences representing the Geological Society,* W. T. SCHALLER.

W. D. JOHNSTON, JR., and G. TUNELL, *Secretaries.*

534TH MEETING

The 534th meeting was held in the Assembly Hall of the Cosmos Club, January 8, 1936, President M. I. GOLDMAN presiding.

Informal Communications.—M. M. KNECHTEL gave new information on the Gila formation of the Gila and San Simon valleys of Arizona. The discovery of fossils in lake beds of the Gila formation allows dating of the formation as Upper Pliocene.

C. M. MILTON described *A foraminiferal—analcite shale from Texas.* In his study of the Terlingua mercury region in Texas in 1934 Mr. C. P. Ross obtained some specimens which showed rather exceptional features. One of them, this rock, is a highly fossiliferous tarry shale, the fossils being foraminifera of the *Globigerina* and *Textularia* types. These of course are too small to be seen with the naked eye; but prominent in the black tarry rock are great numbers of white analcite crystals, each the size of a pinhead or larger.

Analcite is a common mineral in the igneous rocks of the region. One such amygdular rock examined in the laboratory, has analcite both as part of the groundmass, and in the amygdules, where it is associated with quartz, chalcedony, and calcite.

It is of interest that the formation of analcite apparently occurred over a range of physical-chemical conditions: first, as a primary constituent of the igneous rock, second, under conditions of amygdular formation; and lastly in a calcareous shale. Discussed by C. P. Ross.

Program.—WATSON MONROE: *Upper Cretaceous and lower Tertiary history of the Jackson area, Mississippi.* The Jackson anticline is in south-central Mississippi about 40 miles east of the Mississippi River at Vicksburg. The core of the anticline is a deeply buried hill of Paleozoic sedimentary and Cretaceous igneous rocks. The rocks penetrated only in wells range in age from Carboniferous to Claiborne (Eocene). Those exposed at the surface range in age from Claiborne to Recent. Upper Cretaceous rocks overlie the Carboniferous. On the flanks of the Jackson anticline are several thousand feet of Cretaceous rocks not present on the top.

Unconformably overlying the Cretaceous is the lower part of the Tertiary

system consisting of alternating marine and nonmarine beds with disconformities at the top of each nonmarine bed. These disconformities may not represent uplift, but rather submergence of old deltas and coastal swamps. As there is no evidence of uplift of the area except for the disconformities, the lower Tertiary history may be one of subsidence and deposition only.

The only deformations of the bedrock during lower Tertiary time were downwarpings at the beginning of deposition of each marine formation. The structure of the top of the basal Eocene formation (the Clayton limestone) appears in large part to be the result of compaction of small masses of Upper Cretaceous clay on the crest of the anticline and of thick beds of clay on the flanks. The structure gets progressively less complex upward in the section.

Two main factors have influenced the geologic history of the area: First, there was not necessarily any uplift of the bedrock surface in the Jackson area from the beginning of the Eocene until the end of the Oligocene, and second, the structure of the rocks is the result of differential compaction of Cretaceous and Tertiary sediments over and around a buried hill. (*Author's abstract.*)

David A. Andrews: *Suggested Lance-Fort Union correlations in adjacent parts of Montana and North and South Dakota.* With the completion of field work for the Rosebud coal field in 1930 and the Mizpah coal field in 1932, in southeastern Montana, the United States Geological Survey has completed the detailed mapping of the strip that extends eastward from the Big Horn River in Montana to the headwaters of the Cannonball River in North Dakota and the Grand River in South Dakota. These reports describe the Big Horn County, Tullock, Forsyth, Rosebud, Mizpah, Miles City, Baker, Terry, and Ekalaka fields in Montana and the Marmarth and Sentinel Butte in North Dakota and northwestern South Dakota. Other fields joining or lying near this strip which have been mapped in detail are the Bull Mountain, Ashland, Northern Sheridan, Little Sheep Mountain, and Glendive fields in Montana.

Early correlations of the Lance and Fort Union formations in this area, made before completion of this detailed mapping, do not agree in detail with the correlations suggested by compilations from these reports. The Cannonball marine member and the demonstrably equivalent portions of the Ludlow lignitic member, at the top of the Lance formation in North Dakota and South Dakota, are now classified as Cretaceous by the U. S. Geological Survey. Lateral tracing through the Ekalaka, Marmarth, Baker, Terry, Miles City, Mizpah, and Rosebud fields suggests that the Ludlow is equivalent to the basal 200–300 feet of the Tongue River member of the Fort Union as mapped in southeastern Montana. In the Rosebud and Mizpah fields the so-called Lebo shale member at the base of the Fort Union and the Tullock member at the top of the Lance merge eastward into somber colored shales equivalent in large part to the Hell Creek member as mapped in Marmarth and Ekalaka fields and the lower unit of Lance in northwestern South Dakota. Inasmuch as the Tullock and Lebo overlie the Hell Creek near its type locality, the Hell Creek of Ekalaka and adjoining fields probably contains beds younger than type Hell Creek. G. S. Rogers, L. H. Woolsey and others originally correlated the beds in southeastern Montana with the type Lebo of the Crazy Mountains on the basis of high volcanic and andesitic content. Later published material of Coleman Renick and unpublished work of M. N. Bramlette, F. S. Parker, and W. G. Pierce, of the U. S. Geological Survey, who found no microscopic evidence for differentiat-

ing Lebo from the overlying Tongue River and the underlying Tullock, do not confirm the earlier correlations.

It is suggested that the name Lebo should be dropped in southeastern Montana, and Hell Creek should be dropped in extreme southeastern Montana, adjoining parts of North and South Dakota and that some other name be substituted for the somber shale unit of the Lance of that region which does not imply correlations that now appear uncertain or even improbable. Although the basal 200 feet ± of the Tongue River member appears to be equivalent to the Ludlow, it is impracticable and impossible, with data now available, to separate the part equivalent to the Ludlow from the Tongue River. Consequently, it is suggested that the contact between the yellow beds or Tongue River member of the Fort Union and the somber colored beds below (the so-called Lebo shale of Bull Mountain, Tullock, Forsyth, and Rosebud fields), should be taken as the best mappable boundary now known between the Lance and Fort Union in southeastern Montana. Discussed by R. W. Brown, Knechtel, W. C. Mansfield, Stanton, Hess.

James Gilluly: *Pediments of the Ajo region, Arizona.* The smoothly sloping carved-rock plains that commonly front the mountains of the southwestern deserts—to which the name pediment has been applied—have occasioned much discussion among physiographers. There is difference of opinion as to almost every aspect of the pediments, from their shapes to the peculiar causes that determine their formation.

The study of these surfaces has been greatly handicapped in the past by the dearth of good base maps showing them. When Bryan set out to illustrate them, he was forced to fall back on maps of a scale of 1/125000. Part, at least, of the divergent views of these forms is probably due to the fact that quantitative data have been lacking. In the Ajo district an excellent map has recently become available, showing the topography of a considerable area on a scale of 1/48000 and a smaller but representative pediment area on a scale of 1/12000. Studies carried out on these maps furnish the basis for this paper.

Ajo lies in the middle of the Papago country of southwestern Arizona, and the surfaces here discussed have been cited by Bryan as typical pediments. The region is part of the Sonoran desert section of the Basin and Range province. The bedrock structure is dominated by faulting; the latest movement was long enough ago so that many of the faults are represented by fault-line scarps and none of them are directly represented in the topography. The integration of the drainage of this very arid county is additional evidence that the faults are old.

The bulk of the mountains are composed of granitic and gneissic rocks, with some steeply tilted old fanglomerates, andesitic tuffs and breccias and some thick, massive andesite flows. All the rocks except the massive andesite lavas have been carved into sierra topography (mature); the massive andesites form mesas, with sharply cut canyons (young). The pediments are restricted to the fronts of the mature mountains and extend into them for considerable distances along the streams. The andesite mountains are fronted with more or less continuous talus piles that merge gradually into the bahadas—no pediments intervene. The pediments are especially well developed on the softer formations.

In plan, the pediment is convex outward as it must be, of course, to conform to the front of a nearly circular mountain mass. Most of the pediment is concave upward, but along a few of the streams it is convex upward, probably because of stream capture, for adjoining areas on both sides are

concave upward. In transverse profile, the pediment is concave upward with respect to all but one, (possibly two) of the streams. The fan-formed pediment at the mouth of one of the streams occurs within a reentrant of the mountain front. It cannot therefore be explained in the same way as the general convexity of the pediment as a whole nor can it be due to special lithologic factors, as far as known. However, it is at the debouchure of only one (2 ?) of twenty or more comparable streams and must be regarded as exceptional.

The pediment that extends well into the mountains along Darby arroyo has been mapped on the scale of 1/12000 on the Ajo Mining District Special map. Transverse sections of this are uniformly concave upward. Slight addition to the pediment laterally would isolate several of the mountain spurs so that fan form is again not characteristic of the pediment.

The drainage is dendritic high on the pediments and the streams are there sunk about 40 feet into the surface marked by the summits of the interfluves, but the transition from stream to divide is rather gentle. Further down the pediment, the drainage is more or less parallel and the relief of the surface somewhat less in feet but more abruptly concentrated at the channel edges. Near the bahada, the channels are divergent, and sunk abruptly for 10 to 15 feet. Gravel is there widespread, but higher on the pediments it is confined to narrow belts near the streams. The streams meander only in a few places.

It is inferred that the upper parts of the pediments are being lowered by weathering and rill wash. Lateral planation is there negligible as shown by the restriction of the gravel. Farther downstream lateral planation is increasingly important and may eventually dominate in lowering the pediment at the bahada slope. The absence of the pediments from the fronts of the mountains made up of massive andesite shows that weathering is a dominant factor in pediment formation, for although these hard rocks would of course obstruct lateral planation, one might justifiably expect some narrow pediments on even the hardest rocks were lateral planation the dominant factor in their making.

The obvious effectiveness of rill wash and weathering to lower the surface high on the pediments raises the tentative question as to whether pediments may not be born with drainage incisions. That is, this may be the form that pediments normally have when growing headward. Of course the incision of the channels at the lower ends of the pediments is sharp and must indicate a change in stream regimen, but it seems worth while to question whether such an interpretation is required for the more gently transitional incision of the streams below the interfluves that seems characteristic of the upper parts of the pediments. Discussed by Messrs. MATTHES, ANDREWS, RUBEY.

535TH MEETING

The 535th meeting was held in the Assembly Hall of the Cosmos Club, January 8, 1936, President M. I. GOLDMAN presiding.

Informal communications.—O. E. MEINZER read extracts from a letter written by H. T. Stearns, U. S. Geological Survey, Spreckelsville, Maui, T. H., January 3, 1936, describing the recent eruption on Mauna Loa.

"All work in the months of November and December has been overshadowed by the eruption of Mauna Loa. Friends woke me up on the night it broke out (November 21) and I drove to the Lahaina side of West Maui, where I saw a magnificent view of the eruption. The glowing fume cloud rose about 10 miles into the air and even from this distance (more than 100

miles) I could definitely make out the streams of lava. The glow was so brilliant that it was successfully photographed from Oahu.

"I went to Hilo by plane early the next morning, thence to the Kilauea Military Camp, where I got animals to go as far as the Rest House at altitude 10,000 feet. From there up it was a hard hike to the source fountains at 12,500 feet. Reached the fountains at 10 P.M., and kept warm by them even though snow lay on the ground only a mile away. When I arrived 14 fountains were shooting very liquid lava 150 feet into the air, and three rivers of pahoehoe united within 25 feet of where I stood to form one river flowing at the rate of about 25 miles an hour. During the night the temperature of the lava fell slowly so that spatter cones began to form. By morning the fountains had partly walled themselves in and the pahoehoe rivers had slowed down to about 5 miles an hour. The rivers then began to overflow their levees and spread lava at my feet. By 10 A.M., the fountains barely shot above the cones except one lone one away up the rift. By nightfall November 24 all the fountains had ceased except one.

"I then drove around to Hummuula, on the slopes of Mauna Kea, and spent November 26, 27, and 28 at the aa flows. Associated Press broadcasted the news that I was lost but instead I was just having a good time at the lavas. I slept at night with my feet in the aa laid down the day before. The aa advanced at various rates during these days—a mile during one night and the next day only 100 feet an hour. The rate varied chiefly with the slope of the ground over which it flowed. I was fortunate enough to see the fluid aa spread a quarter of a mile in less than an hour through a wooded area. It was only 1 to 3 feet thick and so hot that logs covered by the lava sounded like blast furnaces as they burned and some exploded throwing up hot lava into the air. At night some of the trees burned up in a flash like great Roman candles 100 feet high. In spite of this tremendous heat some of the large trees managed to stand upright in the lava flow with their foliage shrivelled but intact."

Program.—M. N. BRAMLETTE: *Origin of Arkansas bauxite deposits.* Discussed by Messrs. SPENCER, KING, MISER, BURCHARD, RUBEY and HEWETT.

CHARLES V. THEIS: *Possible effects of ground-water on the Ogallala formation of Llano Estacado.* The Ogallala formation, of Pliocene age in the area considered, forms the cap of the Llano Estacado, the part of the High Plains south of the Canadian River in Texas and New Mexico. This variable continental formation is made up of four elements: (1) crossbedded sand and gravel occurring principally in old broad valleys in the sub-Ogallala floor, but also occurring in places at every stratigraphic level in the formation; (2) lithologically structureless silt and fine sand making up about 75 percent of the total mass of the Ogallala; (3) lime-cemented beds forming "caliche" at many horizons in the formation, differing from the previous two elements only in being cemented; and (4) a limestone, several feet thick, capping the remainder of the formation, also generally referred to as "caliche." Overlying red silt up to possibly 100 feet thick, not previously separated from the Ogallala in this area, is considered the probable southern equivalent of the Pleistocene loess occupying the same stratigraphic position northward in Kansas and Nebraska. The petrographic and lithologic character of the gravel deposits indicates that they are channel deposits of streams originating in the mountains to the west. The structureless material making up the bulk of the formation is fine-grained, well sorted, uniform in texture, and makes up the entire mass of the Ogallala throughout outcrops tens of miles long and up to 100 feet thick. These features strongly suggest

an eolian emplacement of material originally derived from alluvial deposits in the channels represented by the gravel in the Ogallala of today and also from similar deposits in the portion of the original High Plains to the west of the present remnants. The limestone at the top of the Ogallala formation is distinct from any other "caliche" bed in the Ogallala and forms the one key bed in the Ogallala that can be traced practically throughout the High Plains from the southern edge of the formation northward at least to Nebraska. The gnarly bedding of the limestone, the inclusion of breccias made up of limestone fragments cemented in a like matrix, the inclusion of widely spaced sand grains and pebbles, and the apparent presence of algal cells, reported by Elias from Kansas, suggest an open-water origin for much, at least, of this limestone.

It appears probable that the water table must have stood at or near the surface in this area throughout at least much of Ogallala time. The thickness of a water body in a permeable mass resting on a sloping impermeable floor is proportional to the distance across it in the direction of dip of the floor, and approximately proportional to the ratio between recharge and permeability of the formation. At present the water table in the Ogallala stands about midway in the formation throughout much of the central part of the Llano Estacado. This position is maintained through rainfall penetration amounting to probably no more than 1/2 inch of water a year, or about 3 percent of the total precipitation. Rainfall penetration at the present time is inhibited by the cover of surficial loessial silt of probable Pleistocene age and by the limestone capping the Ogallala. In Ogallala time these were not present. At that time the Ogallala formation extended much farther both east and west. It was receiving flood run-off from mountain areas to the west, and there were no transecting streams tending to lower the water table. It therefore seems most probable that unless the climate was unduly arid the water table in Ogallala time must have stood so near the surface as to dispose of the excess water by evaporation and transpiration. The presence of grass seeds, discovered by Elias in the Ogallala of Kansas, and of hackberry seeds as far south as the Llano Estacado, seems to indicate that the climate was not severely arid. The area would be visualized as a gently undulating surface with pools perhaps in the lower portions, and the water table within the reach of grass roots over most of the area. The climate would not necessarily be more humid than at present.

The application of this concept to the sediments entails some difficulties in detail, partly occasioned by the absence of detailed information about the deposits, but appears to explain the larger features fairly well. Under such conditions vegetation would probably be encouraged, which would aid in trapping fine sand and silt from the air and at the same time inhibit the formation of dunes, which are apparently absent. The accumulation would tend to build up parallel to the water table and to the underlying impervious floor. In cooler or more moist periods the movement of sand by the wind would be lessened and the water table would rise closer to the surface, thus giving opportunity for greater evaporation and therefore cementation of the surficial sediments. In this way, the sand and silt would be cemented to form "caliche" at certain horizons. As Pleistocene time was approached or entered, with continued cooling and probably greater precipitation the water table would rise closer to the surface, forming more extensive pools in which limestone would be formed by algae or by inorganic means. At the same time, for the same reasons, soil moisture in the areas furnishing the sand to the air would be increased and deflation checked, thus giving an opportunity

for the accumulation of limestone relatively free of sand. A discussion of how large such pools must have been or how much they could have shifted must be deferred until more detailed data are available regarding the lithology and petrography of the limestone. With continued cooling and greater rainfall, as the Pleistocene was well entered, a further rise of the water table would cause overflow of the pools and integration of surface drainage, with consequent rapid dissection and lowering of the water table, eventually to its present position. Discussed by BRADLEY, RUBEY, MEINZER, GILLULY, K. E. LOHMAN, GOLDMAN.

PARKER D. TRASK: *Proportion of organic matter converted into oil in Sante Fe Springs field, California.* All the oil that was in the Sante Fe Springs field at the time the field was discovered is equivalent to a yield of 0.053 percent of the weight of the prism of sediments from which the oil seems to have been derived. As the organic content of these sediments at time of deposition is calculated to be 3.0 percent of the weight of the sediments, the yield of oil therefore would be 0.053/3.0 or 1.8 percent of the organic content of the sediments. This represents the minimum production of oil by the organic matter. The actual quantity that was generated by the source beds presumably was larger, as some oil that was formed may have failed to reach the reservoir. When the possible sources of loss of oil, such as retention by source beds, escape to the surface of the ground, destruction by bacteria and trapping and adsorption while migrating, are considered, the conclusion is reached that the most probable yield of oil by the organic constituents is of the order of magnitude of 4 percent, though it may have been as high as 15 percent. Discussed by SPENCER, J. S. WILLIAMS, HENDRICKS.

536TH MEETING

The 536th meeting was held in the Assembly Hall of the Cosmos Club, February 12, 1936, President M. I. GOLDMAN presiding.

Informal communications.—Mr. E. T. ALLEN reviewed a new book by F. A. Perret, Eruption of Mt. Pelee, 1929–1932. Discussed by M. I. GOLDMAN.

Program.—ADOLPH KNOPF: *The igneous geology of the Spanish Peaks region, Colorado.* Discussed by Messrs. MERTIE, GILLULY, SHENON, R. C. WELLS, STOSE, GODDARD.

F. E. MATTHES: *Erosional processes in the Alpine Zone of the Sierra Nevada.* Discussed by Messrs. MERTIE, CAPPS, BRADLEY, R. F. GRIGGS, FAHEY.

537TH MEETING

The 537th meeting was held in the Assembly Hall of the Cosmos Club, February 26, 1936, President M. I. GOLDMAN presiding.

Informal communications.—L. G. HENBEST described and illustrated peculiar oölite grains from the lower part of the Brentwood limestone, lower Pennsylvanian, near Fayetteville, Arkansas. The majority of these oölites have quartz nuclei of which the greater number are unabraded, euhedral crystals. By darkfield illumination particularly, these nuclei are divisible into two parts—an inner, more or less rounded grain of crystalline quartz and an investment which bears the crystal faces and has simultaneous extinction with the inner grain. The investment contains inclusions which clearly were originally a part of the concretionary structure of the calcareous zone in the oölite; furthermore, the inclusions conform to the contour of the ghost grain in the center of the crystal. Other features also indicate that

the investment is secondary. The investment appears to have formed very slowly and that the silica passed through the walls of the oölite grains after the walls had reached a solid state and probably after the spaces between the grains had been filled with matrix. No reason has been found for supposing that the secondary silica was added during Recent weathering. (*Author's abstract.*)

E. B. ECKEL described oölites forming about gas bubbles in a swimming pool at Pinkerton Hot Springs, Colorado. Discussed by Messrs. FAHEY, GOLDMAN, TRASK, HENBEST.

Program.—A. H. KOSCHMANN: *Structure of the Magdalena mining District, New Mexico.* Discussed by Messrs. KING, HENDRICKS, LOUGHLIN.

G. H. LOUGHLIN: *Ore deposits of the Magdalena mining district, New Mexico.* Discussed by Messrs. PARK, MCKNIGHT, WILLIAMS, KING, HENBEST, SHENON, GODDARD.

538TH MEETING

The 538th meeting was held in the Assembly Hall of the Cosmos Club, March 11, 1936, President M. I. GOLDMAN presiding.

Program: R. C. CADY: *Distribution of Thermal Springs in the United States.*

E. T. ALLEN: *Thermal Springs: criteria of their origin and factors in their differentiation.* All hot springs studied by the writer are regarded as magmatic, (1) because they contain relatively large amounts of chemical elements, especially carbon, sulphur and chlorine, found in rocks only in traces, though all are of common occurrence in hot fumeroles; (2) because their heat is readily accounted for as the result of rising steam, chief among the magmatic gases, while dry rock is low in heat capacity and a poor conductor of heat. The theory that hot springs are bodies of circulating ground water, heated by magmatic steam and enriched by other magmatic emanations which leach from the adjacent rock important amounts of mineral matter, agrees well with a great mass of observed fact. That some thermal springs of low temperature and dilute character derive their mineral matter from rock and atmosphere is possible, but that they are magmatic springs in the last stage of development seems equally plausible. Differentiation of thermal springs into the distinctive types actually found in the field is held to be due (1) to contact of the hot waters with limestone in the case of travertine springs; and (2) where limestone is absent to topography on the one hand, and differences in the volatility of magmatic emanations and their products on the other. Topography controls water supply, and the depth to which water descends in hot ground should be limited by its volume. Thus the nature of the dissolved mineral matter in the waters and the deposits they form are accounted for. (*Author's abstract.*) Discussed by Messrs. GILLULY, R. C. WELLS, SCHALLER, BURBANK, RUBEY, HENBEST, HESS, MEINZER, TRASK, G. R. MANSFIELD, INGERSON.

D. F. HEWETT: *The problem of the warm springs of Georgia.* Discussed by Messrs. ALLEN, BOWLES, WENZEL, S. LOHMAN, CADY, FIEDLER, HENDRICKS, MEINZER.

539TH MEETING

The 539th meeting was held in the Assembly Hall of the Cosmos Club, March 25, 1936, President M. I. GOLDMAN presiding.

Informal communications.—W. W. RUBEY called attention to experiments on stream dynamics soon to be undertaken at the National Hydraulic Laboratory, Bureau of Standards. The effects of damming a graded stream will

be studied. The results of this investigation should be of considerable interest to geologists and physiographers.

G. A. Cooper described a forthcoming monograph on Ozarkian-Canadian Brachiopoda by E. O. Ulrich and G. A. Cooper.

Program.—F. E. Ingerson: *Late glacial and post-glacial history of western Newfoundland.*

H. G. Ferguson and S. W. Muller: *Jurassic thrust faults in west central Nevada.* In the Hawthorne and Tonopah quadrangles in west-central Nevada a belt of thrust faulting is approximately coextensive with the area of Triassic sediments which outcrop in the northeastern part of the Hawthorne and northwestern part of the Tonopah quadrangle.

The Mesozoic sediments involved in the thrusting include a thick volcanic series of Middle Triassic age (Excelsior formation), overlaid unconformably by Upper Triassic (Luning and Gabbs formations) and Lower Jurassic sediments (Sunrise and Dunlap formations). The oldest and thickest of these, the Luning formation, probably did not extend far to the south or east of its present outcrop. The youngest Lower Jurassic formation (Dunlap formation) consists dominantly of fanglomerate, conglomerate and sandstone and is unconformable on the older formations. Its principal distribution is in an irregular belt overlapping the eastern and southern contacts of the Luning and Excelsior formations. Granitic intrusives, regarded as outliers of the Sierra batholith and presumably of late Jurassic age, cut the Mesozoic sediments.

Apparently the first folding resulted in the formation of an irregular trough in which the thickest sections of the Dunlap were deposited. Folding and thrusting continued during the period of Dunlap deposition. The thrusts are older than the granitic intrusives. The date of thrusting therefore, may be placed as about the end of early Jurassic time (end of Lias).

The thrust faults show a noticeable lack of continuity and are irregular in attitude and distribution. In parts of the area there is evidence of movement in nearly opposite directions on different thrusts. As far as evidence is obtainable the movement on individual thrusts was relatively small, possibly of the order of magnitude of one to three miles and without great stratigraphic displacement. Evidence of movement under light load is shown by the combinations of thrust and tear fault characteristic of many of the thrusts and there is direct evidence that several of the thrusts moved over an erosion surface.

A small complex area in the Pilot Mountains shows that locally folding went on contemporaneously with faulting and two of the surface thrusts were folded into overturned anticlines.

The general relations of the structural features of the area are explained on the assumption that a basin-like area of incompetent Upper Triassic and Lower Jurassic sediments suffered compression contemporaneously with the deposition of the youngest member of the series. This compression, principally from northwest, was succeeded intermittently by eastward pressure exerted by the rising Paleozoic land mass bordering the Mesozoic area.

Irregularities of the surface of Middle Triassic volcanics on which the later sediments were deposited may have been effective in localizing and causing minor irregularities of the thrusts and folds.

The field work was carried out in part with the assistance of grants from the Geological Society of America. (*Authors' abstract.*)

G. Tunell and G. A. Cooper, *Secretaries.*

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PALEONTOLOGY.—*A new species of* "Crassatellites" *from the upper Miocene of Florida.*[1] W. C. Mansfield, U. S. Geological Survey.

"Crassatellites" (Hybolophus?) leonensis Mansfield

Crassatellites (*Crassatellites*) *gibbesii* Mansfield, Florida State Geol. Survey. Bull. 8, pp. 80, 81, pl. 16, fig. 9, 1932. (Not *"Crassatellites" gibbesii* Tuomey and Holmes, 1856.)

In the above publication, I identified specimens from the *Ecphora* zone and the *Cancellaria* zone (upper Miocene) of Florida as *Crassatellites gibbesii* (Tuomey and Holmes), a species described from the Waccamaw formation of South Carolina, but stated therewith that the Florida Miocene form was more elongate than the specimens figured by Tuomey and Holmes under their species, *C. gibbesii.* After collecting more specimens of *C. gibbesii* from the Waccamaw formation and the Caloosahatchee marl, I now believe that the upper Miocene form should not be specifically united with the Pliocene form and here refer the Miocene form to a new species *"Crassatellites" leonensis.*

The adult shell of *C. leonensis* differs from *C. gibbesii* in having a much more elongate shell and coarser undulations over the beak. The concentric sculpture on the body of the Miocene shell is also more closely spaced than on the Pliocene shell. The Miocene species probably is a precursor of the Pliocene species.

Dimensions of the holotype (U.S.N.M. 371160).—Length 68 mm, height 47 mm.

Type locality.—Borrow pit, Jackson Bluff, Leon County, Fla.

Outside occurrence.—Two immature specimens collected at Raysors Bridge, Colleton County, S. C., probably belong to the new species here described. The new species probably does not occur at the Natural Well (Duplin marl) of North Carolina—the species *C. undulatus* Say occurring here; nor at Wilmington, N. C., the Pliocene species, *C. gibbesii* occurring here. *"Crassatellites" densus* Dall, a species described from the Oak Grove sand of Florida, has a more prominent posterior dorsal ridge and a smoother area over the middle of the shell than the new species here described.

[1] Published by permission of the Director, U. S. Geological Survey, Washington, D. C. Received June 11, 1936.

BOTANY.—*New species of* Arundinaria *from Southwestern China.*[1]

Y. L. Keng, Academia Sinica, National Research Institute of Biology, Nanking, China. (Communicated by Agnes Chase.)

Arundinaria violascens Keng, sp. nov.

Culmus teres, internodio primo in specimine circ. 14 cm longo, 4.5 mm crasso, dense fasciculato-ramosus, ramulis fere omnibus racemos terminales gerentibus; vaginae ad ramulum ultimum 4–6, glabrae vel saepe puberulae, pleraeque setis fuscis fimbriatae; ligula 0.3–1 mm longa, truncata; laminae 2.5–5 cm longae, 3–5 mm latae, pleraeque involutae, tessellatae, basi in petiolum brevissimum attenuatae, margine utroque scaberulae; racemus basi inclusus, 4–7 cm longus, 3–7-spiculatus, pedicellis erectis, laevibus, 4–14 mm longis; spiculae 5–9-florae, 2.7–4 cm longae, fusco-purpureae; glumae acuminatae, superne puberulae vel interdum glabrae, prima 5–7 mm longa, 3–5 nerva, secunda 7–11 mm longa, 7–9-nerva; lemmata oblongo-lanceolata, acuminata vel in acumen producta, omnino puberulo-scaberula, 9-nervia, venulis transversis reticulata, infimo 12–15 mm longo, callo pilis circ. 1 mm longis dense barbato; palea 9–10 mm longa, bidentata, puberula, ad carinas versus apicem rigide ciliata; lodiculae 3, hyalinae, ovatae, 2–2.5 mm longae, fimbriatae, inferne nervosae; antherae 3, 5–6 mm longae, flavidae; ovarium fusiforme, circ. 2 mm longum, apice in stylos 3 brevissimos divisum, stigmatibus plumosis, circ. 3 mm longis; rhachillae articuli 4 mm longi, versus apicem incrassati pubescensque.

Type in the Herbarium of the U. S. National Herbarium, no. 1214328, collected on mountains south of Likiang, near Hochin and Chiuho, Yunnan Province, May 25–28, 1922, by J. F. Rock (no. 4082).

This species is probably related to *A. Forrestii* Keng (Yunnan: Forrest 14127 in Herb. Kew), from which it differs, however, in having smaller florets, shorter anthers, and shorter but stouter rachilla-joints.

Arundinaria parvifolia Hack., sp. nov.

Culmus (cujus pars superior floriferus tantum adest) teres, tenuissimus, internodiis in specimine 25–33 mm longis, circ. 0.75 mm crassis, ramis solitariis, simplicibus, 8–15 cm longis, racemos terminales gerentibus; vaginae ad ramum floriferum 6–9, imbricatae, 1–2 cm longae, glabrae; ligula 0.3–0.5 mm longa, truncata; laminae (in vagina suprema) circ. 18 mm longae, 3 mm latae, nervo secundario utrinque 1, reticulato-venulosae, tenuiter acuminatae, basi breve angustae, margine altero scaberulae, altero cartilagineo-laeves; racemi basi inclusi, 4–5 cm longi, 5–7-spiculati, pedicellis erectis, laevibus, 1–5 mm longis, infimo spatha circ. 1 cm longa subtento; spiculae 4–6-florae, 15–25 mm longae, viridulae; glumae acuminatae vel in acumen productae, tenues, stramineae, 3–5-nerves, prima 5–6 mm, secunda 6–7 mm longa; lemmata oblongo-lanceolata, acuminata, 7–nervia, trabeculosa, praeter callum pubescens glabra, primo 8–9 mm longo; palea bidentata, lemma aequans vel paulo superans, praeter carinas saepe 6-nervis, laevis vel ad carinas versus apicem scaberula; lodiculae 3, ovatae, 2.5 mm longae, superne ciliatae; antherae 3, 5 mm longae, pallidae; stigmata 2, circ. 2 mm longa, tenuissime plumosa; rhachillae articuli tenues, glabri, 3–4 mm longi.

[1] Received May 27, 1936.

Type in the U. S. National Herbarium, no. 1126301, collected in Yunnan Province but without precise locality, 1910, by E. E. Maire (no. 7532).

This species is characterized by the glabrous rachilla-joints and the palea equaling or exceeding the lemma. Described from a single specimen ex herb. Vienna which bears the name *Arundinaria parvifolia* Hack.

Arundinaria pauciflora Keng, sp. nov.

Culmus in specimine circ. 40 cm longus, 3 mm crassus, internodiis in parte superiore teretibus, 4.5–9.5 cm longis, nudis, glabris, dense fasciculato-ramosus, ramis primariis usque ultra 20 cm longis et iterum ramulosis, racemos terminales plerisque gerentibus; vaginae ad ramulum floriferum ultimum pleraeque 3–6, imbricatae, glabrae vel ad collum et prope margines pubescentes, apice setis fuscis scaberulis saepe fimbriatae; ligula circ. 0.5 mm longa, truncata; laminae 1–3 cm longae, 3–6 mm latae, acuminatae, basi in petiolum brevissimum attenuatae, firmae, tessellatae, subtus glaucae, supra pubescentes, nervis secundariis utrinque 2–3, margine altero scabrae, altero fere cartilagineo-laeves; racemus inclusus vel demum breve exsertus, 2–3 cm longus, plerusque 3–spiculatus, pedicellis erectis, laevibus, 2–4 mm longis, bractea glumacea 2–3 mm longa saepe subtentis; spiculae 4–5-florae, 16–21 mm longae, leviter purpureae; glumae inaequales, glabrae vel interdum versus apicem ciliolatae, prima ovata, acuta, 3–4 mm longa, 1–3-nerva, secunda abrupte acuta, 6–7.5 mm longa, 7–9-nerva; lemmata ovato-lanceolata, acuminata, 7–9-nervia, reticulato-nervosa, glabra vel ad nervos puberula, infimo 8–12 mm longa, callo albo-pubescente; palea angusta, 7–8 mm longa, ad carinas superne ciliata; lodiculae 3, ovatae, 1.5–2 mm longae, fimbriatae; antherae 3, 5 mm longae, terminate exsertae; stigmata 2–3, plumosa, 2–3 mm longa; rhachillae articuli incrassati, 2.5–4 mm longi, margine apiceque ciliati, dorso item adpresso-pubescentes.

Type in the U. S. National Herbarium, no. 1128976, collected at Shao-shan, Ningyuen region, Szechuan Province, altitude 2700 meters, April 15, 1914, by Handel-Mazzetti (no. 1365).

This species is probably related to *A. brevipaniculata* Hand.-Mazz., but is distinguished by the racemes of a few spikelets.

BOTANY.—*A* Fusarium-*like species of* Dactylella *capturing and consuming testaceous rhizopods.*[1]

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Agar plate cultures, started from diseased rootlets or other decaying plant materials that previously have been in prolonged contact with the soil, usually allow the gradual multiplication of various species of testaceous rhizopods, some of which often attain large numbers in the course of two or three weeks. Once a population of these animals has become established, it is in general less subject to rapid decline than the populations of animal types multiplying more

[1] Received August 31, 1936.

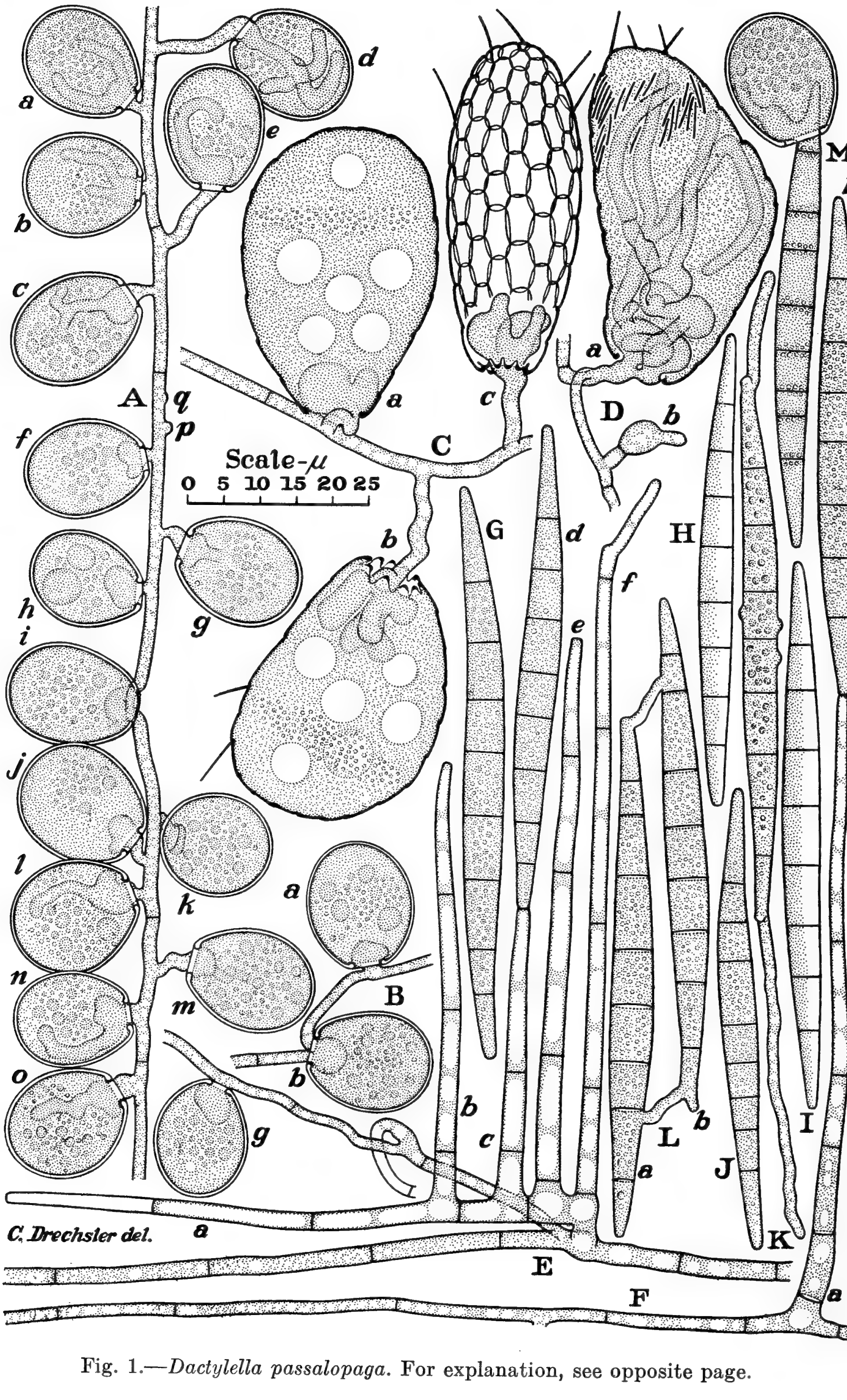

Fig. 1.—*Dactylella passalopaga*. For explanation, see opposite page.

rapidly in agar cultures, including, for example, many species of nematodes and many of the smaller amoebae. This lesser tendency toward abrupt reduction in number of living individuals, appears in considerable measure to be due to infrequence of destruction by parasitic or predacious fungi. In view of the disasters often overtaking populations of amoebae from the development of members of the Zoopagaceae (4, 5, 7) it might be expected that shelled rhizopods, whose protoplasmic bodies are necessarily partly protruded for feeding and locomotion, would suffer serious depredations from the same group of conidial Phycomycetes. Yet only two members of the Zoopagaceae, which will be described elsewhere, have so far been found to subsist on testaceous rhizopods. *Difflugia globulosa* Duj. and *Trinema enchelys* Ehrenb. were shown in an earlier paper (3) to be captured and consumed by *Pedilospora dactylopaga* Drechsl., a fungus referable to a quite different predacious series. This series, consisting of hyphomycetous forms belonging mostly to the genera *Trichothecium, Arthrobotrys, Dactylaria* and *Dactylella* (including *Monacrosporium*), is destructive mainly to nematodes. The biological relationship of *P. dactylopaga* would seem, therefore, to be a somewhat unusual one; as would also the similar relationship of an apparently allied fungus recently observed to subsist by the capture of two other species of shelled rhizopods.

The scanty vegetative mycelium of the fungus in question might readily be overlooked in a mixture of microorganisms but for the conspicuous alignment of captured prey in two ranks, with oral ends directed toward one another (Fig. 1, A-D). Because of the large numbers in which it develops in old agar plate cultures, the smaller

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Fig. 1.—*Dactylella passalopaga*, drawn from material developed in mixed culture on maizemeal agar, with the aid of a camera lucida, at a uniform magnification; ×1000. A.—Portion of hypha on which fifteen specimens of *Geococcus vulgaris*, *a–o*, have been captured; the two slight protuberances *p* and *q*, possibly representing predacious modifications. B.—A short portion of hypha with two captured specimens of *G. vulgaris;* one, *a*, having been taken without positional disturbance of the filament; the other, *b*, having drawn the hypha partly into its mouth as in feeding. C.—Portion of hypha with three specimens of *Euglypha laevis*, each held by means of a lobed predacious gag; two of the animals, *a* and *b*, being shown mainly in optical section, the other, *c*, mainly in surface view. D.—Portion of hypha with (*a*) a captured specimen of *E. laevis*, within which are shown assimilative hyphae arising from the lobes of the predacious gag; and (*b*) an enlargement representing probably an outgrowth from which a rhizopod managed to escape. E.—Portion of mycelium showing an old, partly evacuated, prostrate conidiophore, *a*, that has given rise to four younger erect conidiophores, three of which, *b*, *c* and *e*, have each produced a single terminal conidium, and the other, *f*, in addition, a second conidium on the oblique distal prolongation; all the conidiophores being shown denuded except *c*, whereon conidium *d* is shown in position. F.—Portion of hypha with a conidiophore, *a*, bearing a conidium, *b*. G. H, I, J.—Detached conidia. L.—Two germinating conidia, *a* and *b*, the single germ tube from each having fused with a segment of the other conidium. M.—A conidium showing early predacious development following partial ingestion by a specimen of *G. vulgaris*.

rhizopod having a broadly ovoid, smooth test slightly thickened about the circular mouth, and otherwise corresponding well to Francé's description (8) of his *Geococcus vulgaris*, provides an especially striking display. Frequently the individual hyphae are beset for long stretches with the ovoid animals, here and there at such close intervals that the test of one will be in contact with that of its neighbor on either side (Fig. 1, A). A somewhat less abundant but still impressive display of predacious activity is furnished in the capture of an ovoid or often somewhat unsymmetrically bursiform species of *Euglypha*, measuring usually 35 to 50μ in length and provided with aperture scales noticeably thickened at their slightly incurved apices (Fig. 1, C, D). In morphology the animal evidently corresponds most closely to the description of *E. laevis* Perty as given in the accounts of Penard (13) and of Cash and Wailes (1); for though in some individuals a few rudimentary bristles may be present at the aboral end, a completely glabrous condition is by far more common.

Examination of tracts of mycelial filament free of the two species of rhizopods mentioned, has not revealed any distinct structure to which a special function in the capture of prey could be assigned. Some slight protuberances to be found now and then on vegetative hyphae (Fig. 1, A, *p*, *q*), or even on germinating conidia (Fig. 1, K), may possibly represent predacious modifications, but their meager differentiation is hardly at all suggestive of any important role. The swollen parts, sessile or stalked (Fig. 1, D, *b*), that are occasionally seen and that in some degree resemble the well defined predacious organs of *Dactylella tylopaga* Drechsl. (6) and of *Pedilospora dactylopaga*, are very similar to the processes formed after prey has been engaged, and in all probability represent outgrowths from which animals have managed to escape. An absence of definite organs of capture previous to encounter with prey, is unusual among the predacious Hyphomycetes, the only other example of such absence known in this series being found in the nematode-capturing species of *Dactylella* with quadrilobate conidia figured in another paper (2: Fig. 9, A, C).

The necessity for special organs to initiate capture is apparently obviated by the feeding habits of the animals on which the fungus preys. As *Geococcus vulgaris* is a relatively small testaceous rhizopod with a proportionately small aperture, it might be expected that feeding would be restricted to objects like bacteria and the more minute of fungus spores. Such limitation, however, does not actually prevail, for often the animal obtains its nourishment from objects as formidable as the oospore of *Pythium ultimum* Trow, which not only

exceeds it in size, but is surrounded, moreover, by the thick and thoroughly substantial oospore wall. Oospores of *P. ultimum* and of many congeneric forms are, of course, consumed by other rhizopods flourishing in agar plate cultures: some of the larger species of *Amoeba* often enveloping a specimen until the durable wall is broken down and the protoplasmic material assimilated; while the robust testaceous *Arcella vulgaris* Ehrenb., with its capacious oral aperture, often "imports" one specimen after another, so that three or four oospores in various stages of digestion may be seen inside. Neither of these more usual modes of ingestion is followed by *G. vulgaris,* which instead, applies its mouth flush to the oospore wall, calks the zone of contact with a yellow secretion apparently identical with the substance closing up the test during periods of encystment, and gradually perforates the delimited portion of spore wall, probably by some sort of digestive action. Once communication is established with the interior of the oospore, the granular contents, now visibly degenerating, are drawn into the test of the animal,—the movement of material appearing much the same as in the sucking of an egg.

When mycelium is attacked by *Geococcus vulgaris* the delay incident to the resistance of the thick oospore wall is obviated, and the sucking action becomes evident while the filament is still intact. No exception is made of the hyphae belonging to the predacious fungus herein under consideration, as a filament of this species is often to be seen drawn into the mouth of an animal (Fig. 1, A, *i;* B, *b*). To such undiscriminating voracity the fungus responds by rapidly proliferating from the partly ingested portion a bulbous outgrowth slightly larger than the oral aperture, so that the rhizopod is securely held. Indeed, more generally, the fungus meets the animal half way, by putting forth the expanded outgrowth before suffering any physical change itself. In many instances the expanded part is nearly sessile on the filament (Fig. 1, A, *a, b, c, f, g, h, j, k, l, n, o;* B, *a*), but in other instances it is formed on a short branch (Fig. 1, A, *d, e, m*). The rangier connection apparently is brought about when the animal, after making contact with the filament, moves away, and is pursued through elongation of the outgrowth until the expanded part has attained a width making further movement impossible.

The same sequence of events is followed also in the capture of *Euglypha laevis.* Because of the larger mouth of this rhizopod, a correspondingly bulkier gag is required to effect capture; the additional requirement being supplied through the proliferation of a number of expanded lobes (Fig. 1, C) in place of the simple distended part. Like-

wise, as might be expected, the assimilative hyphae thrust into the interior of the larger animal (Fig. 1, D, *a*) are longer and more numerous than those of the meager haustorial apparatus discernible, mostly with difficulty, in some specimens of *Geococcus vulgaris*. The exhaustion of materials from either rhizopod takes place without causing any sudden conspicuous change in appearance of the sarcode, the protoplasmic contents merely becoming more and more tenuous, much like the protoplasm of amoebae attacked by members of the Zoopagaceae, or like the contents of *Amoeba verrucosa* Ehrenb. attacked by *Dactylella tylopaga*.

After a mycelium has been nourished for some time, erect conidiophores arise singly (Fig. 1, F, *a*) or in small groups (Fig. 1, E, *b, c, e, f*) from the rangy prostrate filaments. They show unmistakable similarity to the homologous structures of *Pedilospora dactylopaga*, though noticeably stouter and shorter in stature. When growing in mixed culture in the presence of bacteria, the conidiophore usually concludes its development with the production of a single rather massive terminal conidium (Fig. 1, E, *d;* F, *b*). In some instances, however, it grows out from below the attachment of the first spore to produce a second farther on (Fig. 1, E, *f*); or, fairly often, it gives rise through lateral branching to one or more secondary conidiophores, under the increasing weight of which it is pressed down into a prostrate position. (Fig. 1, E, *a*). Though the conidium in its septation and elongate-fusoid shape bears a suggestive resemblance to the conidia of some species of *Fusarium*, it lacks the distinctive basal modification frequent in that genus, and is never borne on a sporodochium (Fig. 1, G–J). Germination takes place readily, by the production usually of two germ tubes, one from each end (Fig. 1, K). Anastomoses of germ tubes with detached conidia (Fig. 1, L, *a, b*) or with mycelial filaments, and, indeed, vegetative fusions generally, are frequent in this species, as in other members of the predacious series of Hyphomycetes. Occasionally newly detached conidia are partly ingested by *Geococcus vulgaris* (Fig. 1, M), so that at times vegetative germination may be preceded by predacious development.

The morphology of its conidial apparatus makes the fungus clearly eligible for inclusion in the genus *Dactylella* Grove. Of the several forms described in this genus, *D. minuta* var. *fusiformis* Grove (9) offers apparently the closest resemblance, though the greater diameter (7 to 9μ) and more abundant septation (9 to 12) ascribed to the conidia of the British species, would seem to exclude any strong likelihood of identity. Similarity in varying degree is recognizable also

when comparison is extended to the several species with narrow conidia that have been compiled in the genus *Monacrosporium* Oud. Thus *M. subtile,* as described and figured by Oudemans (12), approaches the predacious form under consideration in diameter of conidium, but presents fairly decisive differences in the clavate shape and more abundant septation of that structure. The pronouncedly clavate shape illustrated in Harz's original publication (10), together with the inferior length (35 to 38μ) and less abundant (3 to 5) septation, also sufficiently distinguishes the conidia of *M. sarcopodioides* (Harz) Berl. et Volg. On the other hand, the conidia of *M. oxysporum* Sacc. and March. (11) are described as being symmetrically spindle-shaped; yet their very acutely pointed ends emphasized in Marchal's drawings, their greater length (96 to 105μ) and width (9 to 10.5μ), and their more frequent (10 to 12) septation, not to mention the greater length (120 to 170μ) and width (4 to 5μ) of the supporting conidiophores, constitute details not reconcilable with the asexual reproductive apparatus found in my cultures.

The fungus so curiously adapted to prey on small-mouthed testaceous rhizopods is believed, therefore, to represent a new species, for which a name having reference to the gaglike predacious structure would seem appropriate.

Dactylella passalopaga sp. nov.

Mycelium sparsum, repens, parce ramosum; hyphis sterilibus 1.2–2.7μ crassis, hyalinis, mediocriter septatis, ex latere in ores animalium ramulum trudentibus qui intus tumet et sic animalia tenet; hyphis fertilibus paucis, solitariis vel parum aggregatis, hyalinis, plus minusve erectis, saepe 2–5-septatis, 40–110μ altis, basi 2.8–4μ crassis, sursum attenuatis, apice 1.2–1.8μ crassis, unicum conidium vel interdum secundum post incrementum ferentibus. Conidia hyalina, elongato-fusoidea, utrimque obtuse rotundata, 60–80μ longa, 4.5–6μ crassa, 6–8-septata.

Habitat in radicibus plantarum putrescentibus, in terra, saepe in humo silvarum, Geococcum vulgarem et Euglypham laevem capiens et consumens, prope Beltsville, Maryland.

Mycelium sparse, creeping, rather scantily branched; the vegetative hyphae 1.2 to 2.7μ wide, hyaline, septate at moderate distances, capturing some species of small-mouthed testaceous rhizopods by thrusting into the mouth of the individual animal a short lateral branch that expands inside to form a simple or lobed enlargement wider than the aperture; conidiophores usually few in number, scattered singly or in small groups, hyaline, more or less erect, mostly 2 to 5 (average 3.3) times septate, 40 to 110μ (average 69μ) in height, 2.8 to 4μ (average 3.3μ) wide at the base, tapering upward to an apical diameter of 1.2 to 1.8μ, bearing usually a single conidium and sometimes a second one on a distal prolongation originating immediately below the base of the first. Conidia hyaline, elongated spindle-shaped,

bluntly rounded at both ends, 60 to 80μ (average 69μ) long, 4.5 to 6μ wide, and divided usually by 6 to 8 (average 7.7) cross-walls.

Capturing and consuming *Geococcus vulgaris* and *Euglypha laevis*, it occurs in decaying plant roots, in soil, and especially often in leaf mold, near Beltsville, Maryland.

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ZOOLOGY.—*New millipeds of the American family Striariidae.*[1]

H. F. Loomis, U. S. Plant Introduction Garden, Coconut Grove, Florida. (Communicated by O. F. Cook.)

The milliped family Striariidae is composed of a single genus containing species found only in the United States. The first species was described in 1888 by C. H. Bollman, who recognized it as the type of the genus *Striaria*, later designating a new subfamily for its accommodation. In 1895 O. F. Cook elevated the subfamily to full family rank, and in 1896 gave it position as a suborder of the Coelocheta, on the same footing as the Lysiopetaloidea and the Chordeumoidea, like the Chordeumoidea in the short body of 30 segments, and like the Lysiopetaloidea in having the segments longitudinally carinate, but contrasting with both these groups in the slow movements and heavily armored structure, with the head reduced and protected by the greatly expanded first segment, the lower carinae strongly developed, and the last segment broadly three-lobed, affording protection when the animals are coiled, as in several specialized families of the order Merocheta.

[1] Received June 18, 1936.

In 1899 Cook formulated descriptions of the order, its three subdivisions, and of the family, genus and type species, *Striaria granulosa* Bollman, and also added two new species, one from the District of Columbia, while the other, based on a female specimen, extended the distribution of the group to California. The next and last addition to the genus was made by R. V. Chamberlin, in 1910, of another species, from Portland, Oregon, also based on a female specimen.

In the material which led to the preparation of the present paper were two new species, both from California, giving a preponderance

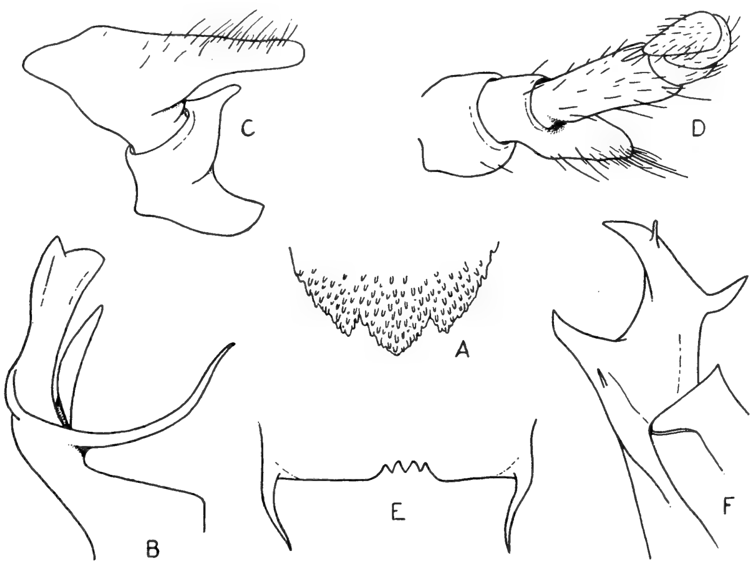


Fig. 1.—Structural features of *Striaria*. A. *S. nana*, last segment. B. *S. nana*, lateral view of apical two-thirds of anterior portion of a gonopod. C. *S. nana*, left posterior gonopod from behind. D. *S. imberbis*, second leg of male. E. *S. californica*, labrum of male. F. *S. californica*, lateral view of apex of anterior gonopod.

to the Pacific Coast. Also there were many specimens of *S. californica* Cook, from the males of which it has been possible to amplify the original description of the species.

The characters shown by the new species, and additional specimens of some of those previously known, force the modification of several statements which have been made pertaining to the characters of the genus *Striaria* or higher classification units. Dorsal setae, in the same number and position as in the Chordeumoidea, were found in four species examined and are inferred to be present in those not seen. Only in specimens of *S. nana* were these setae found in complete series, but careful inspection of examples of the other species us-

ually showed a few setae still remaining on some of the segments, especially those near the ends of the body, although most of the setae had been broken off. The disposition of these setae is as follows: On the first segment six setae are found a little back of the front margin, in front of the dorsal crests. The ensuing segments also have six dorsal setae, three on each side of the dorsum, the first located between ridges 1 and 2, the second between ridges 3 and 4, and the third between ridges 5 and 6. Segment one and the last segment are without a median ridge, while the other segments have a pronounced ridge on the anterior subsegment but none on the posterior subsegment, its place being occupied by a fine distinct groove. The shape of the male labrum is reduced in value to a specific character with the discovery that in at least one species, and possibly another, the lateral corners are not developed into spines. In one species the pregenital legs of the males are not conspicuously heavier than the other legs.

Characters for the recognition of the six members of the genus are given in the following key.

KEY TO THE SPECIES OF STRIARIA

Size small, not over 7 mm long; ventral crests beyond segment 12 or 13 reduced or obsolete.................................. **nana** n. sp.
Size larger, at least 10 mm long; ventral crests present on all but two or three of the last segments..

First segment with 12 dorsal crests or ridges.........**nazinta** Chamberlin
First segment with 10 dorsal crests..

Body strongly flattened, especially in front; labrum similar in both sexes; second male legs with a very large lobe projecting from beneath the second joint.....................................**imberbis** n. sp.
Body cylindrical or only slightly flattened; labrum of males with lateral corners produced into long spines; second male legs with lobes small or wanting..

Body reaching 15 mm in length; males with the anterior margin of the labrum nearly straight between the median teeth and the produced spine on either side.................................**californica** Cook
Body less than 12 mm long; male labrum with anterior margin strongly convex between the median teeth and the lateral spines................

Dorsal crests very coarse; lobes of the last segment separated by distinctly open sinuses; apex of anterior gonopods terminating in about six short spines or teeth...............................**granulosa** Bollman
Dorsal crests finer; lobes of the last segment separated by shallow notches rather than by deep and slender sinuses; apex of anterior gonopods terminating in about a dozen sharp teeth..........**columbiana** Cook

Striaria nana n. sp.

Six mature specimens, including the male type, and several young, collected at Altamont Pass, above Niles, Calif., December 1, 1926, by O. F. Cook, who found a single female south of Pescadero, Calif., February 21, 1929. Male type in U. S. National Museum.

Diagnosis: The small size of the body; presence of all or nearly all dorsal setae; the lack of ventral crests on the posterior half of the body; and the shape of the gonopods distinguish this species.

Description: Body small, the dorsum somewhat depressed on the first few segments, but cylindrical thereafter; dorsal setae generally all present; length 6 to 7 mm, width .7 to .8 mm.

Head with not over 7 ocelli each side. Labrum of male broad, outer corners sharply angled but, unless broken from the two specimens examined, without spines.

First segment with 10 dorsal crests; surface elsewhere finely and densely granular as are the ensuing segments, including their lateral surfaces. Median ridge of the anterior subsegments fine but well elevated, the depression on either side of its posterior part much less extensive than in *S. californica* or *S. imberbis.*

Second segment with the surface bearing the ventral crest scarcely at all produced outward beyond the line of descent of the side, not forming a nearly horizontal projecting shoulder as in *S. imberbis*. Interval between the ventral crest and the lowest dorsal crest a little wider than the next interval above.

Large ventral crests present on the segments in front of the middle of the body, the anterior corner of each crest slightly produced forward and bluntly rounded; on the posterior segments the ventral crests are reduced to small low elevations or are entirely lacking. Last segment with the lateral lobes smaller in proportion to the median lobe than in the other species, and all lobes more acute; dorsal surface covered with slender suberect tubercles (Fig. 1, A).

Males with first pair of legs stouter than the second pair. Second legs lacking a conspicuous lobe on the under side of joint 2, the other joints also normal. Third legs with each coxa produced into an erect subcylindric lobe relatively as long as found in *S. granulosa*, the inner face glabrous and shining, the outer side finely hispid; remaining joints normal. Legs 4 to 7 with the four basal joints very greatly expanded horizontally but not thickened, their surface covered with short, stout, fusiform, almost scale-like hairs, in contrast to the common type of hairs found on the other legs. Anterior gonopods with the apex bilobed, not at all spinose (Fig. 1, B). Posterior gonopods with the distal joint more greatly produced inward than in the other species, the lobe thinner (Fig. 1, C).

This small species was at first thought to represent a new genus because of the presence of dorsal setae in the same position as they occur in the Chordeumoidea, but careful inspection of other species of *Striaria* showed nearly all individuals to have a few dorsal setae still in evidence, although it was apparent that most of the setae had been broken off. Immature specimens of these species show the setae in more complete series.

STRIARIA NAZINTA Chamberlin

Ann. Ent. Soc. Amer., **3**: *242-243. 1910.*

A single female, discovered at Portland, Oregon, is the only known specimen.

The presence of 12 dorsal ridges on segment 1 is the species' most striking character, 10 ridges being the usual number in the other species, with occasionally an additional, small, rudimentary ridge on one or both sides of this segment in some specimens.

Although the description states that the labrum has only two teeth, and the illustration shows this condition, it is doubtful if other specimens exhibiting this feature would be found, since a three-toothed labrum is an ordinal character of the Coelocheta.

Striaria imberbis n. sp.

A mature male and female and a number of young, the eldest of which have 26 segments, collected south of Atascadero, Calif., January 1, 1928, by O. F. Cook. Male type in U. S. National Museum.

Diagnosis: This species is distinguished by the flattened dorsum; the similarity of the labrum in both sexes; the unusually prominent lateral production of each side of segment 2 supporting the ventral crest; and the very large lobe of the second joint of the second male legs.

Description: Length of male 10 mm, female 12 mm, width 1 and 1.2 mm respectively.

Head narrower in front than in the other species; labrum of the male similar to that of the female, the lateral corners broadly rounded; ocelli 5 to 7 arranged in two irregular rows.

Second segment with the lateral surface which supports the ventral crest much more strongly projecting than in the other species, the interval between the marginal crest and the lowest dorsal crest double the width of the next interval above. Dorsum of the segments depressed throughout, but the anterior ones more strikingly so. Posterior subsegments relatively longer than in the other species. Dorsal crests high but much thinner than those of *S. columbiana*. Surface between the crests with numerous granules on the anterior segments but caudally the granules decreased in size and number; on the lateral surfaces only the anterior segments have a few granules; however, the last segment is densely covered with fine granules. Ventral crests extending to the posterior end of the body, those in front with the anterior corner projecting forward as a large acute tooth. Median ridge very prominent on the anterior subsegments, especially those in front, the depression on either side of its back half is more extensive than that in *S. californica*. Last segment with the lobes very narrowly, although deeply, separated, the median lobe much the largest.

Gonopods of the type not dissected but the apex of the anterior portion does not appear to be spinose; the shoe-like posterior joints are of the same general shape as in the other species. First legs of the male stouter than the second pair; the latter with a very large, bluntly conic lobe projecting outward and backward from the under side of the second joint, the posterior side and apex with long hairs (Fig. 1, D); other joints normal. Coxal lobes

of the third male legs considerably shorter than in the other species of which males are known. Legs 4 to 7 of the male with none of the joints conspicuously enlarged as compared with the post-genital legs, their surfaces invested with similar hairs.

Striaria californica Cook

Proc. U. S. Nat. Mus., **21**: *675. 1899.*

Specimens collected by O. F. Cook in the following California localities have been examined: Santa Cruz Mts., Jan. 2, 1928; Cordelia, Feb. 20, 1929; Davenport, Feb. 21, 1929. Several males are included which allow more tangible characters to be given than from the single female on which the species was founded.

Body attaining a length of 15 mm, making the species the largest of the genus.

Eyes with 7 to 9 ocelli. Males with the labrum produced at each corner into a long spine, the margin between the spine and the median teeth almost straight in contrast with the strongly convex margin of the other species (Fig. 1, E).

Segment 1 and a few segments succeeding it rather thickly and coarsely granular, the granules thereafter decreasing in size and number and, except those bearing the dorsal setae, none are evident on the segments immediately preceding the anal segment, the surface of which is densely but finely granular. Sides of body without granules after the first few segments. Anterior subsegments, particularly those at the front of the body, with a median ridge which is especially pronounced on the posterior part of each subsegment, and the surface on each side is depressed to the level of the posterior subsegment which has a fine median furrow but no ridge. Second segment with the lateral surface supporting the ventral crest scarcely at all produced outward to form a strong shoulder as in the other species; the interval between the ventral crest and the lowest dorsal crest little broader than the interval between crests 5 and 6. Ensuing segments, to near the posterior end of the body, with thick ventral crests, those on the anterior segments bluntly produced forward.

Gonopods with the apex of the anterior portion more simple than in either eastern species (Fig. 1, F); shoe-like joint of the posterior portion thickest near its mesial extremity. The second male legs have joint 2 bearing a much smaller, more inconspicuous lobe on the under side than that in *S. imberbis*, but with longer apical hairs; joint 3 greatly swollen except at base; outer joints normal. The third male legs have the coxal lobes longer than in the other species, their tips exceeding the distal end of joint 3. Male legs 4 to 7 with the inner joints quite strongly crassate, the outer joints more normal.

Striaria granulosa Bollman

Ann. N. Y. Acad. Sci., **4**: *108. 1888.*

Locality: Tennessee.

Striaria columbiana Cook

Proc. U. S. Nat. Mus., **21**: *674–675. 1899.*

Localities: District of Columbia and Maryland.

ZOOLOGY.—Anguillulina askenasyi (*Bütschli, 1873*), *a gall forming nematode parasite of the common fern moss,* Thuidium delicatulum (*L.*) *Hedw.*[1] G. STEINER, Bureau of Plant Industry.

There are quite a few records of the occurrence of nematode galls on mosses from Europe, but, as far as known to the writer, there are no such records from this country. All previous observations were

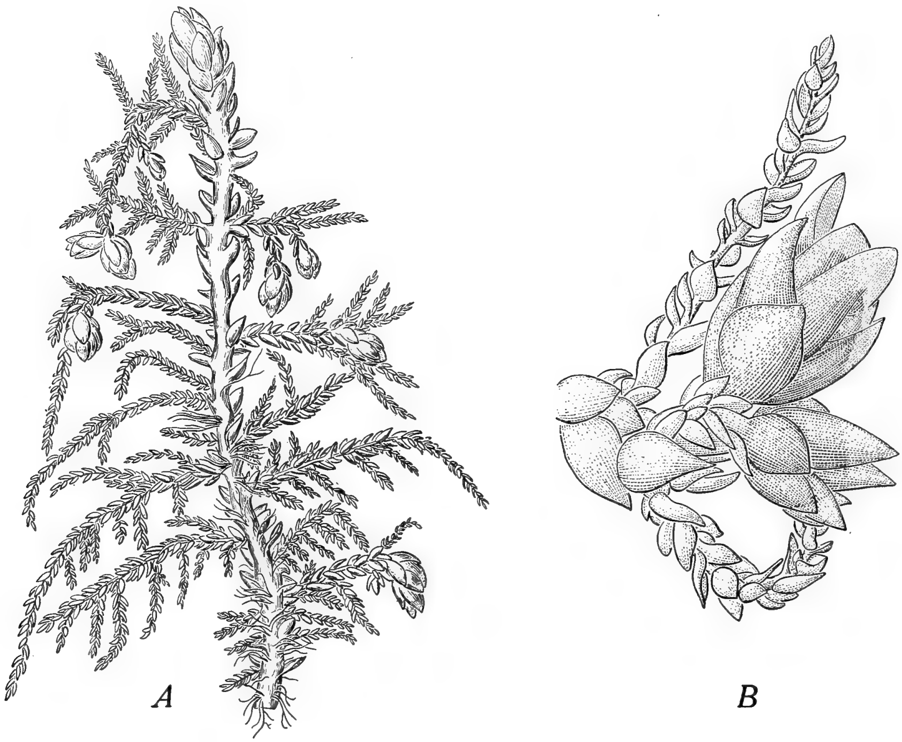


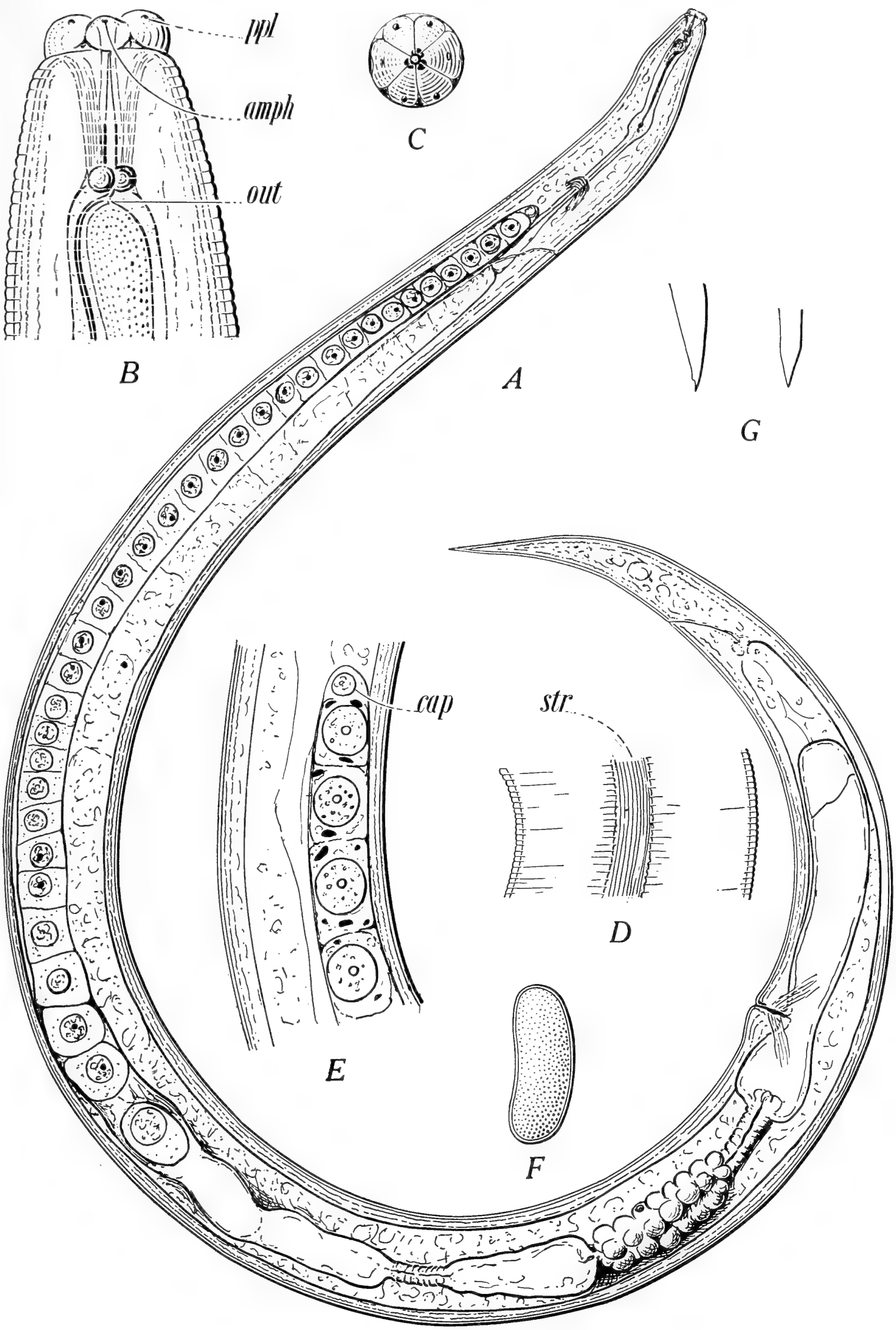
Fig. 1.—*Thuidium delicatulum* (L.) Hedw. with galls caused by the nematode *Anguillulina askenasyi* (Bütschli). *A*, stem and branches with terminal galls. ×6. *B*, detail of two galls. ×24.

summarized in 1906 by Schiffner and further additions reported later by Horn (1909).

Through Mr. J. L. Sheldon of Morgantown, West Virginia, a sample of *Thuidium delicatulum* with galls was received with the inquiry as to the name of the nematode species present. The moss had been collected in a wood across the road from the old Iron Furnace, near

[1] Received June 5, 1936.

Fig. 2.—*Anguillulina askenasyi* (Bütschli). *A*, female. ×370. *B*, head end of female; *amph*, amphid; *ppl*, cephalic papilla; *out*, outlet of dorsal esophageal gland. ×1900. *C*, front view of head of male. ×1900. *D*, striated lateral field in adult; *str*, striae. ×1900. *E*, proximal end of ovary; *cap*, cap cell. ×730. *F*, egg. ×250. *G*, variations in terminus of tail. ×330.



For explanation of Fig. 2 see bottom of opposite page.

Albright, Preston County, West Virginia, on September 21, 1935. *Thuidium delicatulum* is a member of the family *Thuidiaceae* (*Musci*) and is a species occurring in moist woods in Europe, Asia and on this continent from Labrador to the Rocky Mountains, south to the West Indies and South America.

The galls, measuring .680–.716 mm by .868–.877 mm, are terminal galls, found on the stem as well as on the branches. They closely resemble those described by Massalongo (1898) as caused by *Tylenchus* (*Anguillulina*) in *Zieria julacea* Schimp., and are of the artichoke type (see Fig. 1), having no side shoots or any resemblance to the witches broom type of galls as described from some other mosses, e.g. *Dicranum*. The leaves on the galls are enlarged to a size greater than the branch leaves or even the stem leaves. Their color is the same green as that of the plant. They are densely set on the oval gall, the outline of which may be recognized through them. From all appearances it is concluded that the galls render the branches and stems blind; they probably drop in a later stage. Each gall usually contains a small number of adults (7 to 12) with some 200–300 larvae and eggs. Although the moss had been dried for 8 months, the larvae and adults revived after a short period of soaking.

Description of the nematode (Figs. 2–3). The present parasite markedly resembles *Anguillulina dipsaci* (Kühn, 1858) Gerv. & v. Ben., 1859, with which it was formerly synonymized in spite of the clear-cut statement by Bütschli that it is different (J. Ritzema Bos and al.). The body, however, is much stouter than in the true *A. dipsaci*, although the present specimens were not quite as stout as those described by Bütschli under the name *A. askenasyi* (Bütschli, 1873) from the moss, *Hypnum cupressiforme* Hooker. Cuticle with rather fine annulations, 1μ wide; tail pointed, sharply in adults, much less in the larvae. Lateral fields about 1/5 of body diameter in width; larvae with two edging striae and a middle longitudinal stria; adult with about 10 much finer longitudinal striae; annulation interrupted on lateral fields. Head sharply set off, somewhat rounded, with rather plain submedial papillae. Framework light. Buccal stylet short, finer and smaller than in *A. dipsaci*. Terminal esophageal bulb distinctly set off from intestine, with esophageal glands still within the bulb. Intestine with large cells, seemingly in double alternate series. Rectum and anus very fine, often even obscure, especially in the adult. Excretory pore in adults ventrad of terminal esophageal bulb; in larvae ventrad just back of nerve-ring. Female apparatus with postvulvar sac-shaped uterus usually extending more than half the distance vulva-anus. Ovary most often straight, rarely reflexed, with terminal cap cell (Fig. 2, E). Outlets of ovary well differentiated, with oviduct leading into receptaculum seminis; latter differentiated from uterus proper by distinct narrow duct. Eggs deposited unsegmented. Male testis straight, not reflexed. Spicula much like those of *A. dipsaci*, with lineate gubernaculum of about 1/3 spicula length. Bursa rises suddenly a short distance behind, or level with, proximal spicula end, in most specimens reaching only about halfway down the tail, rarely a little farther; in a male with a tail

of 103μ, it extended to a distance of 64μ back of the anus. *A. askenasyi* is considered a good species and is herewith reestablished. The original form was observed only once, namely by Bütschli, in Germany, on the moss, *Hypnum cupressiforme*, where, according to this author, it induces certain transformations in terminal buds, without, however, producing galls. It lives between the leaves of the buds of this moss. Although resembling *dipsaci*, it differs from it by being stouter, by having a longer esophagus, in

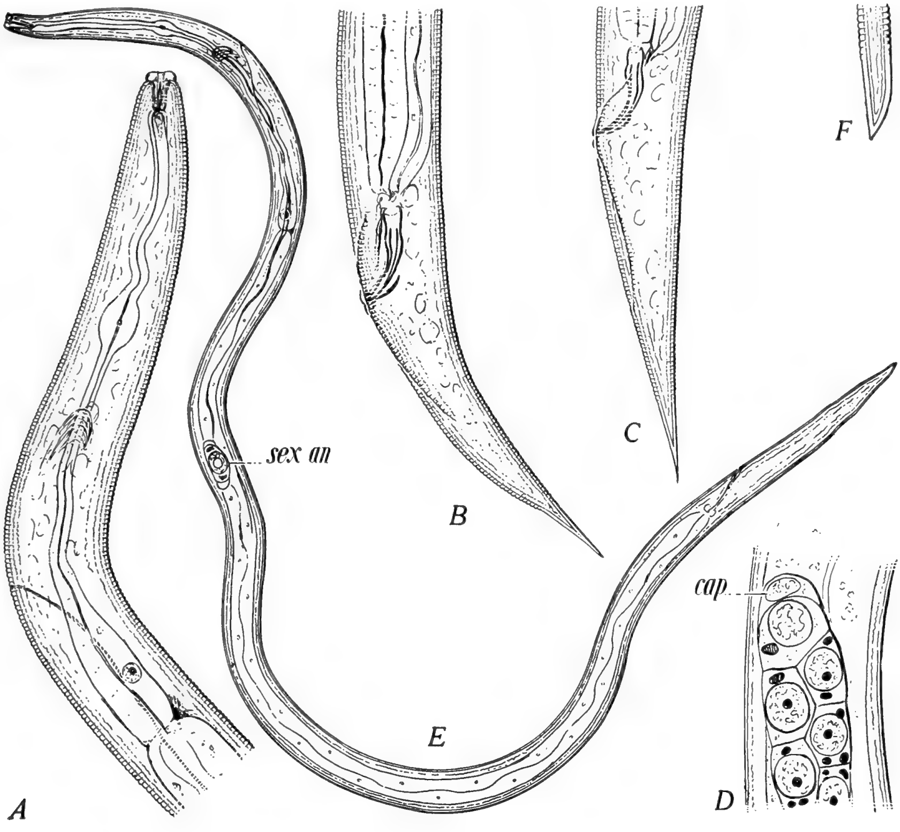


Fig. 3.—*Anguillulina askenasyi* (Bütschli). *A*, anterior end. ×420. *B* and *C*, two different male tail ends; in *C* the bursa beginning farther back than in *B*. ×420. *D*, proximal end of testis; *cap*, cap cells. ×640. *E*, larva of .648 mm length; *sex an*, sexual anlage. ×330. *F*, terminus of larval tail. ×640.

both sexes a longer tail, an intestine of brownish color, and a shorter bursa in the male which reaches only about halfway, or slightly farther, down the tail. In addition the vulva has a more anterior position. Adults of the present species usually take a "more or less rolled-up" spiral position.

Gall forming nematodes in mosses in the past have been referred to *Anguillulina davainii* (Bastian, 1865); whether correctly or not cannot be stated at present, the published descriptions being rather incomplete.

Measurements of specimens from Thuidium delicatulum: ♀ (n 10) total length = .980–1.2 mm; $\alpha = 23\text{–}31$, $\beta = 8\text{–}11.5$, $\gamma = 8.5\text{–}12.8$, $\nu = 73\%\text{–}78\%$.

Distance vulva-anus = about twice length of tail; eggs 36–41$\mu\times$80–100μ; stylet 8–10μ. ♂(n 5) total length = .92–1.2 mm; α=24–31, β=8.1–10.7, γ=8.5–14.5; spicula about 30μ; gubernaculum 8–10μ; stylet 8–10μ.

Measurements as given by Bütschli for the type form: ♀ = 1.7 mm; α=19, β=10, γ=13; ν=80%; eggs = 50$\mu\times$95μ; stylet = 13μ. ♂ = 1.4 mm; α=20, β=10, γ=12.

Emended diagnosis of A. askenasyi: Resembling *A. dipsaci* but stouter, vulva more cephalad, bursa shorter, reaching only half, or slightly more than halfway, down the tail; eggs much thicker, deposited unsegmented; intestine of brownish color; female usually assuming shape of a sickle or a more or less rolled-up spiral.

Type host: Hypnum cupressiforme Hooker.

Type locality: Feldberg, Taunus (Germany).

In view of the difference in symptoms as caused by Bütschli's type form (ectoparasite, not producing galls) and the present form (entoparasite, producing galls), it is thought best to consider the two as different host varieties, a conception also supported by slight differences in dimensions.

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ZOOLOGY.—*The histology of nemic esophagi. VII. The esophagus of* Leidynema appendiculatum (*Leidy*, 1850.)[1] B. G. CHITWOOD, Bureau of Animal Industry, and M. B. CHITWOOD.

This paper is the seventh of a series dealing with the histology of nemic esophagi. In the earlier papers (1934–1936) the esophagi of *Rhabdias eustreptos, Oesophagostomum dentatum, Heterakis gallinae Metastrongylus elongatus, Rhabditis terricola* and *Rhabditis lambdiensis* have been described. The nomenclature used in this paper was explained in the first paper of the series.

GROSS MORPHOLOGY

The length of the esophagus of *Leidynema appendiculatum* usually ranges from 396 to 448μ in the gravid female, but in the gravid female upon which subsequent measurements are based, it is 364μ long. It consists of a cylindri-

[1] Received March 13, 1935.

cal precorpus, 126μ long, a subcylindrical postcorpus, 108μ long, a very short narrow isthmus, 36μ long, and a pyriform bulb, 64μ long. The lumen is triradiate; in the corpus and isthmus each radius terminates in an incomplete subcylindrical "tube." The "tubes" are very wide in the precorpus (Fig. 2a), very narrow in the postcorpus (Fig. 2c), and scarcely distinguishable in the isthmus. In the bulb region the sides of the radii converge; in this region the lumen is, of course, modified by the valves. Returning to the lumen of the corpus, we find that in the precorpus the central part of the lumen is open, subtriangular with thickened walls (Fig. 2a–b), while in the postcorpus and isthmus the lumen is closed, not subtriangular and the walls not thickened (Figs. 1b and 2c–d).

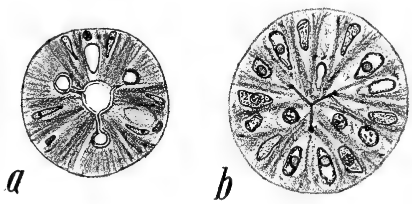

Fig. 1.—Cross section of esophagus. a, Region of precorpus in adult; b, region of postcorpus in adult.

The esophagus of the female fourth-stage larva in the specimen studied is 218μ long and consists of the same parts as in the adult, i.e., precorpus, postcorpus, isthmus and bulb, but the postcorpus is not as wide and the isthmus is very slightly longer. In addition we find that the "tubes" at the ends of the esophageal radii are not as large, the lumen of the precorpus not subtriangular, and its walls not thickened as in the adult.

NUCLEAR DISTRIBUTION

The distribution of nuclei in the esophagus differs slightly in the fourth-stage larva and in the adult. In general, the nuclei are closer together in the larva than in the adult, which is due to the esophagus being shorter; a few of the nuclei differ also in relative position. The nuclei are identical in both stages and for that reason the esophagus of the adult is described, differences in relative position being noted as they occur.

Precorpus.—There are 25 nuclei in the precorpus as follows: 6 radial nuclei (r_{1-6}) and 19 nerve cell nuclei (n_{1-19}). The radial nuclei are situated near the base of the precorpus, and arranged in a single group (r_{1-6}), 1 nucleus on each side of each sector. The nerve cell nuclei are arranged in groups of 3, one in the center of each sector. The first group (n_{1-3}) is situated near the anterior end of the precorpus, the second, third, and fourth groups, (n_{4-6}, n_{7-9}, and n_{10-12}), respectively, follow one another rather closely in series. These are followed by the fifth group (n_{13-15}) which immediately precedes the radial nuclei of the precorpus (r_{1-6}) and the sixth group (n_{16-18}) which is situated

at about the same level as the radial nuclei. The nuclei n_{13} and n_{16} may be identical but in the majority of sections they appear to be separate. In addition to these nuclei there is a single dorsal nerve cell nucleus (n_{19}) situated posterior to n_{17}. In the fourth-stage larva the last 2 subventral nerve cell nuclei are situated at the level of n_{19} instead of at the level of n_{17}. The radial nuclei (r_{1-6}) are situated near the level of n_{10-15} instead of n_{13-18}.

Postcorpus.—There are 22 nuclei in the postcorpus as follows: 3 bilobed marginal nuclei ($m_{1-3a \text{ and } b}$), 6 radial nuclei (r_{6-12}), and 13 nerve cell nuclei (n_{20-32}). The radial nuclei (r_{7-12}) are situated anterior to the middle of the postcorpus and arranged in the same manner as those (r_{1-6}) in the

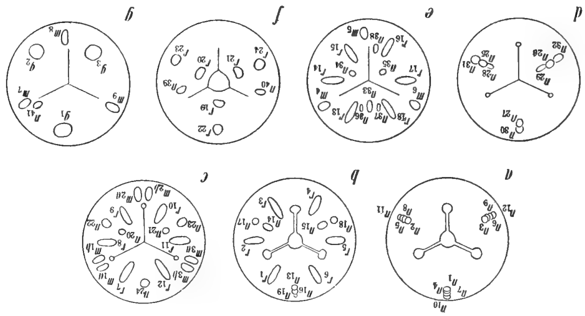

Fig. 2.—Diagrammatic representation of groups of nuclei of esophagus. a–b, Precorpus; c–d, postcorpus; e, prevalvar region; f–g, valvar and postvalvar regions.

precorpus. The marginal nuclei (m_{1-3}) are situated at approximately the same level, 1 lobe of a nucleus being on each side of each esophageal radius (Fig. 1b, m_{1a} and m_{1b}). The nerve cell nuclei (n_{20-32}) are arranged symmetrically in the subventral sector but not in the dorsal sector and for that reason they will be located according to sector. The dorsal sector contains 3 nuclei ($n_{24,27,30}$) the first (n_{24}) being at the level of the radial nuclei (r_{7-12}), the second (n_{27}) some distance posterior to the radial nuclei, and the third (n_{30}) at the base of the postcorpus. Each subventral sector contains 5 nerve cell nuclei ($n_{20-21,22-23,25-26,28-29,31-32}$). The first pair ($n_{20-21}$) is situated slightly anterior to the level of the radial nuclei, near the lumen of the esophagus, and the second pair (n_{22-23}) is situated at the same level or slightly posterior to the first pair and nearer the external surface of the esophagus. The third subventral pair (n_{25-26}) is situated just anterior to the level of n_{27}; the fourth pair (n_{28-29}) is situated posterior to the level of n_{27}, being near the external surface of the esophagus; the fifth pair (n_{31-32}) is at approximately the same level as, or slightly posterior to, the fourth group (n_{28-29}). The nerve cells in the fourth-stage larva differ in that n_{20-23} are situated at the level of r_{7-12}, n_{25-26} at the level of n_{27}, and n_{31-32} at the level of n_{30}.

Isthmus.—The isthmus contains no nuclei.

Prevalvar and valvar region.—This region contains 20 nuclei as follows: 9 radial nuclei (r_{13-21}), 3 marginal nuclei (m_{4-6}), and 8 nerve cell nuclei (n_{33-40}). The radial nuclei are arranged in 2 groups, an anterior group of 6 nuclei (r_{13-18}) arranged as are those in the corpus (r_{1-12}), and a posterior group of 3 nuclei (r_{19-21}), 1 near the center of each sector. The nerve cells are arranged as follows: n_{33} in the middle of the dorsal sector just posterior to the level of $r_{13 \text{ and } 18}$; $n_{34 \text{ and } 35}$ near the middle of each subventral sector at the same level as n_{33}; n_{36-37} are situated just posterior to n_{33}, 1 on each side of the dorsal sector; n_{38} is situated near the ventral radius in the right subventral sector at approximately the same level as r_{21}; n_{39-40} are situated posterior to r_{14-17}, respectively, 1 in the lateral part of each subventral sector.

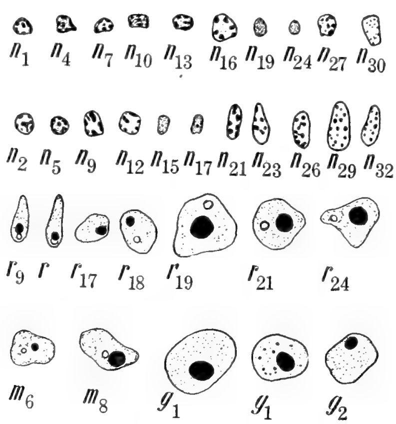

Fig. 3.—Nuclei of esophagus. Marginal, radial, gland nuclei and nuclei of nerve cells.

Postvalvar region.—The postvalvar region contains 10 nuclei as follows: 3 radial nuclei (r_{22-24}), 3 marginal nuclei (m_{7-9}), 3 gland nuclei (g_{1-3}), and 1 nerve cell nucleus (n_{41}). The marginal nuclei (m_{7-9}) are situated near the anterior end of the postvalvar region, 1 being posterior to the other 2. One is situated near each esophageal radius, the side at which each nucleus lies being inconstant. The radial nuclei (r_{22-24}) are situated slightly posterior to the marginal nuclei, 1 near the lumen and in the center of each sector. The gland cell nuclei (g_{1-3}) are similarly arranged except that they are posterior to the radials and near the external surface of the esophagus. The single nerve cell nucleus (n_{41}) is situated beside the left subdorsal radius of the esophagus at about the level of the gland cell nuclei.

THE ESOPHAGO-INTESTINAL VALVE

The esophago-intestinal valve consists of an internal trilobed mass of tissue and an external circular layer of tissue. Within the trilobed mass are

2 nuclei, 1 dorsal (e_1) and 1 ventral (e_2). The number of nuclei in the external layer could not be determined with accuracy. Three nuclei, 1 left and 1 right dorsolateral (e_{3-4}) and 1 right or left subventral (e_5), were consistently found. Two additional dorsolateral nuclei (e_{6x-7x}) were found external to e_{3-4} in one specimen. However, it is possible these nuclei might be those of intestinal cells.

CHARACTER OF NUCLEI

The radial nuclei all contain a moderately large karyosome. The nuclei of the precorpus (r_{1-6}) are laterally compressed, and have a clear, lightly basophilic nucleoplasm (Fig. 1a). The second group of radial nuclei are similar in shape to those of the first group but larger (Fig. 1b). The nucleoplasm is slightly less basophilic, the karyosome larger than the karyosomes of r_{1-6}, and a smaller plasmosome is often visible (Fig. 1b). The nuclei of the third group of radials (r_{13-18}) are similar to those of the second group but more or

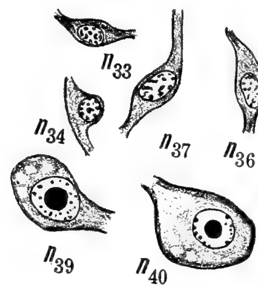

Fig. 4.—Nerve cells.

less ovoid; the nucleoplasm is lightly basophilic, nearly homogenous and each also contains a moderate-sized karyosome and a smaller plasmosome (Fig. 3). The nuclei of the fourth group (r_{19-21}) are rounded in shape, distinctly larger than the others, and each contains a very large karyosome as well as a small plasmosome (Fig. 3). The nuclei of the fifth group (r_{22-24}) are similar to those of the fourth group, but tend to be slightly flattened (Fig. 3).

The marginal nuclei are similar to the radials in general character but the nucleoplasm appears to be more reticular (Fig. 3). Each of the marginal nuclei of the postcorpus (n_{1-3}) consists of a posteriorly bilobed body which in cross section appears as 2 nuclei (Fig. 3), each containing a moderate-sized karyosome and a small plasmosome. The marginal nuclei (m_{4-6}) are not lobed but tend to be irregular in shape due to pressure from the marginal fibers; each contains a large karyosome and a small plasmosome (Fig. 3a). The marginal nuclei (m_{7-9}) are ovoid and similar to m_{4-6}.

The nuclei of the esophageal glands (g_{1-3}) are similar in general character to those of the radial nuclei r_{19-24} in having a large karyosome, small plasmosome, and delicately basophilic nucleoplasm (Fig. 3a); in some specimens

small clumps of granules occur in the nucleoplasm. The dorsal gland nucleus (g_1) is the largest nucleus of the esophagus, the subventrals (g_{2-3}) being but slightly smaller.

The nuclei of the nerve cells (n_{1-41}) differ from all other nuclei of the esophagus and are similar to one another in that the nucleoplasm contains large basophilic clumps (Fig. 3a) which make them much darker than other nuclei; in general neither karyosome or plasmosome may be observed. The nerve cell nuclei fall into 3 general groups as follows: Small nuclei ($n_{1-19,24,27}$), about 1.15 to 3.3μ long by 1.2 to 2.9μ wide in cross section, with rather coarse basophilic deeply staining material; medium-sized nuclei ($n_{23,25-26,28-38,41}$), about 3 to 5.9μ long by 1.87 to 2.6μ wide in cross section, with fewer basophilic clumps in proportion to the size of the nucleus; large nuclei (n_{39-40}), about 5 to 5.9μ long by 4.3 to 4.5μ wide in cross section. The nuclei of the first type belong to bipolar neurones of the 3 anterior esophageal nerves. The cell bodies of these neurones are extremely narrow. The neurones of the second and third types appear to be commissural nuclei of the postcorpus and bulbar regions. These neurones of the second type have moderate-sized cell bodies (Fig. 3b) and those of the third type have massive cell bodies (Fig. 3b).

ESOPHAGEAL GLANDS

The dorsal esophageal gland opens into the lumen of the esophagus at the anterior end of the precorpus. Its duct and finer structure are similar to those of the dorsal esophageal gland of *Rhabditis* (see Chitwood and Chitwood, 1936). It is difficult to trace the glandular protoplasm in the bulb and particularly to distinguish between it and the sarcoplasm of muscle cells. The large nucleus (g_1) apparently lies within the gland tissue, but it may not; we have attributed the nucleus r_{19} to radial muscle, although there is the possibility that it should be attributed to the dorsal gland, and g_1 to the radial muscle; further study is necessary to determine this point with certainty.

The subventral esophageal glands open into the lumen at the posterior end of the postcorpus near the level of n_{30}. They also are similar to the esophageal glands of *Rhabditis* except that they are situated near the middle of the subventral sectors in the bulbar region and not in the lateral part of these sectors. The same difficulties were encountered regarding the nuclei of the glands as were encountered in the case of the dorsal gland. It is possible that the nuclei r_{20-21} should be attributed to the glands and that g_{2-3} should be attributed to the radial muscles. However, the interpretation which the writers have given to these nuclei seems to be correct.

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ZOOLOGY.—*The systematic position of* Indostomus paradoxus *Prashad and Mukerji, a fresh water fish from Burma.*[1] ROLF L. BOLIN, Hopkins Marine Station of Stanford University. (Communicated by WALDO L. SCHMITT.)

The interrelationships between the sticklebacks, tubemouths, pipefishes, and their relatives have long mystified systematists. The families have been shuffled and reshuffled by Starks,[2] Regan,[3] Jungersen,[4] Gregory,[5] and others into various groups, orders, suborders, and superfamilies in an effort to express their evolutionary history. In spite of careful and painstaking research, the problem still remains unsettled and the natural system obscure. The most doubtful point is the question of whether the Gasterosteoidea (including the families Gasterosteidae and Aulorhynchidae) show affinity to the Scleroparei or to the Hemibranchii and Lophobranchii.

The Indostomidae of Prashad and Mukerji,[6] based upon their new species, *Indostomus paradoxus*, from Indawgyi Lake, Myitkyina District, Upper Burma, is the most recently described family to be allocated to this systematic complex. Although of extreme interest as a possible indicator of the mutual relationships of the other families of the group, it has as yet been discussed only by its authors who state, "This new family is closely allied to the family Solenostomidae and to a certain extent to the Syngnathidae of the order Solenichthys Regan, but differs from either in several important characters."

Through the courtesy of Dr. G. S. Myers of the United States National Museum, I have been able to examine a cotype of *Indostomus paradoxus*. It displays many interesting featuies and I am convinced that Prashad and Mukerji erred in considering it closely related to the Solenostomidae and Syngnathidae. If we analyze the characters used by these authors to define the family Indostomidae and to differentiate it from its relatives, it appears that the family's affinities are to be sought in more primitive groups than those suggested.

The general body form, although possibly of minor significance, more closely approximates that of the Aulorhynchidae than it does that of any of the other families, certainly far more closely than it approximates that of the Solenostomidae or Syngnathidae. The de-

[1] Received September 5, 1936.
[2] STARKS, E. C. Proc. U. S. Nat. Mus. **25**: 623–625. 1902.
[3] REGAN, C. T. Biologia Centralia Americana: x–xi. 1908.
[4] JUNGERSEN, H. F. E. Kgl. Dankse Vidensk. Selsk. Skrift. (7) Naturv. & Math. **8**: 329–334. 1910.
[5] GREGORY, W. K. Trans. Amer. Philos. Soc., N.S. **23**: 228–229. 1933.
[6] PRASHAD, B. and D. D. MUKERJI, Rec. Indian Mus. **31**: 219–220. 1929.

pressed head and caudal region of the Aulorhynchidae are very suggestive of *Indostomus,* the main proportional differences, though of minor significance, being the slightly greater depression and more robust build of the thoracico-abdominal region of *Indostomus.* It should also be noted that, except for the greater caudal attenuation and the depressed instead of compressed body, *Indostomus* rather closely approximates the hemibranchiate family Aulostomidae.

When the fins are considered, we find the same relationships suggested. *Indostomus* has two dorsal fins, the first one composed of short spines unconnected by membrane, the second having its origin immediately behind the last dorsal spine. This condition is duplicated in the Aulorhynchidae and the Aulostomidae and is far different from the two complete and widely separated dorsals of the Solenostomidae and the single dorsal of the Syngnathidae. The anal fin of *Indostomus* differs from that of the Aulorhynchidae only in lacking a small spine at its anterior end, and from that of the Aulostomidae only in having its rays branched instead of simple. The latter difference also characterizes the second dorsal of these forms.

The pectorals and pelvics of *Indostomus* are similar in size and position to those of the Aulorhynchidae. From the Aulostomidae, *Indostomus* differs in having its pelvics in a more anterior position. This difference appears to be of relatively minor importance when compared to the marked differences existing between the normal pelvics of *Indostomus* and the inordinately enlarged fins of the Solenostomidae or the totally absent fins of the Syngnathidae. Further, the pelvics of *Indostomus* are composed of four rays, not one spine and three rays as stated in the original description, the outer ray being enlarged and unbranched, but jointed. This is the condition found in the Aulostomidae and differs from that found in the Aulorhynchidae as well as the Solenostomidae. The two latter families have a well developed spine in the pelvic fin.

The armature of the body in *Indostomus* is very similar to that of the Syngnathidae and, in all probability, strongly influenced Prashad and Mukerji to consider it a close relative of the pipefishes. It must be remembered, however, that such armature has been developed in many widely separated families. We find it in the Loricariidae, the Ostraciidae, and the Agonidae, and while the importance of the bony scutes should not be minimized, neither should their importance be unduly stressed because of the conspicuous nature of the character. Its significance as an indicator of close relationship in the case under discussion is somewhat diminished by the contradictory evidence of

the body form and is much overshadowed by the evidence of the fins. Finally, the Aulorhynchidae are also equipped with bony scutes, although they are deeply imbedded and restricted to narrow median and lateral bands.

Prashad and Mukerji state that *Indostomus* is without teeth. A careful examination of the cotype reveals moderately broad bands of minute, villiform teeth on the premaxillary and dentaries, another feature in which the species in question is similar to both the Aulorhynchidae and Aulostomidae and one in which it differs from the Solenostomidae and Syngnathidae.

The nostrils of *Indostomus* I find to be single on each side, appearing as an elongated slit. This is clearly shown in Prashad and Mukerji's excellent figures, although they state that there are two nasal openings and indicate in their table that these are similar to the double nostrils of the Syngnathidae. The single opening is somewhat more extensive than that of the Aulorhynchidae and is clearly different from the double openings of the Aulostomidae and Syngnathidae, but is hardly to be compared to the open nasal organ of the Solenostomidae.

The Indostomidae are said to have "four complete lobate gills." The Syngnathidae, however, of all the fish which I have been able to examine, are the only ones in which the gills are so sharply modified in form and structure that they deserve the special designation lobate. The gills of the Solenostomidae, although equipped with comparatively few filaments, represent only one extreme in a very wide but even numerical variation, and do not differ in basic form from the gills of other teleosts. In the number and shape of the filaments *Indostomus* is intermediate between the Aulorhynchidae and the Aulostomidae on the one hand and the Solenostomidae on the other.

The lateral line system of *Indostomus* is much reduced. Small pores in the interorbital space, behind the eye, on the occiput, and just anterior to the upper end of the gill opening indicate that the supraorbital, infraorbital and supratemporal canals are present. This condition is similar to that found in the Centriscidae, and is intermediate between that of the Aulorhynchidae and the Aulostomidae with their well developed lateral line systems and that found in the Solenostomidae and Syngnathidae without any lateral line system at all.

The final analysis of the relationships of *Indostomus* must depend upon osteological investigations. Unfortunately, the species is so small (the only available specimen is 26 mm in standard length) that osteological investigation of such diagnostic characters as the pres-

ence or absence of some of the pterygoid or branchial elements is impossible without macerating. This I have been unable to do, as the cotype which I have examined is apparently the only specimen of the species in this country and is too valuable to destroy.

Of the known osteological characters, the sutural connection of the post-temporal with the cranium is indicative of relationship to the Hemibranchii and Lophobranchii. On the other hand, the fact noted by Prashad and Mukerji that none of the anterior vertebrae are fused indicates that *Indostomus* is not closely related to these groups, but belongs instead with or near the Gasterosteoidea.

The branchiostegals are 5 in number on the cotype, not 6 as recorded in the type description. This number closely approximates that found in the Aulorhynchidae, 4; equals that found in some of the Aulostomidae, 4–5; and is markedly different from the much reduced number found in the Solenostomidae, 1; and also the Syngnathidae, 1–3.

From the available evidence it seems that the Indostomidae can claim no very close relationship to any known family. The only character tending to link it to the Lophobranchii is the nature of the armature. The majority of characters, the body form, fins, teeth, lateral line system, anterior vertebrae and branchiostegals, indicate that its relatives should be sought among the Gasterosteoidea or Hemibranchii. Of the families comprising these two groups, the Aulorhynchidae and Aulostomidae are by far most similar to the Indostomidae. The latter family appears in many respects to occupy an intermediate position and serves as additional evidence of the relationship of the Gasterosteoidea to the Hemibranchii. While this relationship may not be close enough definitely to validate the questionable order Thoracostei, it is much closer than the relationship of the Gasterosteoidea to the Scleroparei which was suggested by Jungersen.

ENTOMOLOGY.—*A redisposition of* Monoxia puncticollis *and allied species.*[1] Doris H. Blake. (Communicated by Austin H. Clark.)

LeConte, in his treatment of *Galeruca* in 1865, divided the genus into five groups, the fifth group consisting of two species, *G. maritima* and *G. morosa*, both described by him. In 1885 he added a third species, *G. erosa*. These three species have been synonymized by Horn with *Monoxia puncticollis* (Say). LeConte had never been able to

[1] Received May 22, 1936.

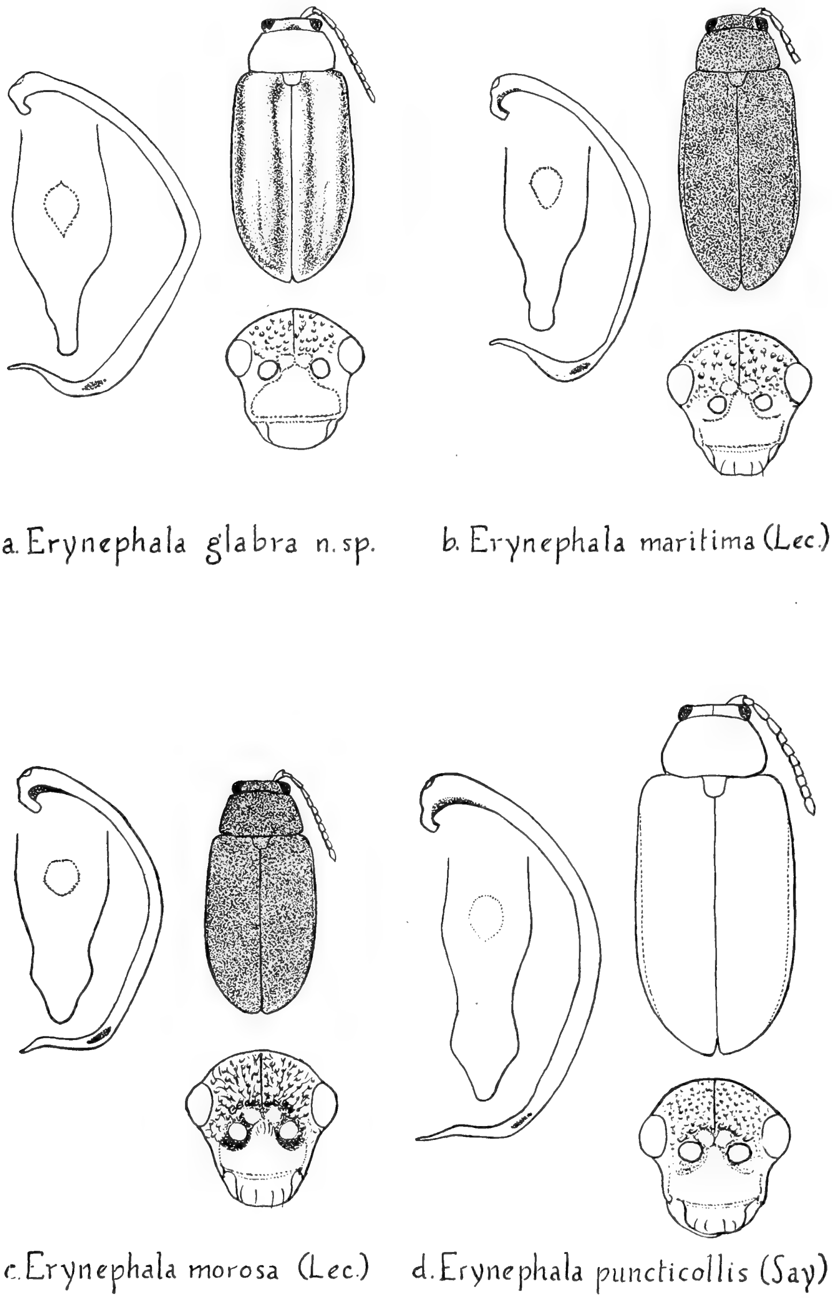

Fig. 1.—a. *Erynephala glabra* Blake, type, Sierra de Durango, Mexico. b. *Erynephala maritima* (Lec.), type in LeConte collection; Gulf States. Genitalia from specimen from Wollaston, Mass. c. *Erynephala morosa* (Lec.), type in LeConte collection; San Francisco, Calif. Genitalia from specimen from Alameda, Calif. d. *Erynephala puncticollis* (Say), type of *G. erosa* Lec. in LeConte collection. Genitalia from specimen from Salt Lake, Utah.—Habit, about 5×; front of head, about 10×; genitalia in dorsal and lateral view, much enlarged.

determine what species Say had before him in describing *G. puncticollis*, and at one time "was disposed to think" it might be related to *Monoxia debilis*. Horn used more than a page in attempting to show that the three species described by LeConte are in reality all forms of Say's species *G. puncticollis*. The fact that these species are all twice as large as Say's measurements of *puncticollis* he dismissed as a slip of the pen on Say's part. Even if this measurement was an error by Say, there is still some objection to placing these very unlike species in LeConte's homogeneous group of *Monoxia*, and still more to reducing to one species three that have very definite and distinctive characters.

These three species agree with the majority of the species of *Monoxia* in one respect,—the claws of the male are toothed and of the female simple. Otherwise the two groups are not closely related, and I agree with Dr. Böving,[2] who found their larval characters entirely different from those of the smaller species of *Monoxia* and with LeConte, who never did incorporate them in that genus, that they should not be put with *Monoxia*. Although Dr. Böving does not find much difference between the larva of *puncticollis* and that of *Galerucella notata*, the mature beetles do not bear any close resemblance to species of the latter genus. Therefore it has seemed best to set this homogeneous group aside in a separate genus.

Erynephala, new genus

The genus *Erynephala* is separated from *Monoxia* (1) by its longer and differently shaped head, (2) by its differently shaped prothorax, which is widest near the base and is not obliquely truncate at the basal angle, and the disc of which is not channelled in the middle or depressed on the sides as in *Monoxia;* (3) by its pygidium, which is not deflexed, as is usually the case in the male of *Monoxia;* (4) by its much longer and differently shaped aedeagus; (5) by its different larval habits (the larvae of *Monoxia* are leaf miners, and the larvae of *Erynephala* feed in the open); (6) by its different larval characters, as shown by A. G. Böving.

The genus *Erynephala* is separated from *Galerucella* (1) by its shorter antennae; (2) by its differently shaped prothorax; (3) by its claws, which are simple in the female and toothed in the male; (4) by its longer and quite differently shaped aedeagus.

Erynephala includes four closely related species, three of which occur in the United States, and one which is known only from the Sierra de Durango in western Mexico. Although *E. puncticollis* (Say) was the first to be described, *E. maritima* is designated as the type of the genus because of the somewhat doubtful application of Say's name. Of the United States species, *maritima* is known to occur from Halifax, N.S. to Texas, and there is one species labeled Jamaica in the Bowditch collection at Cambridge. The second species, *puncticollis*, is known from Texas (inland) to Manitoba in

[2] Böving, A. G., Proc. U.S.N.M., **75**: 29. 1929.

the Great Plains and Rocky Mountains, and has also been collected in the Federal District near Mexico City, Mexico. The third species, *morosa*, is known only from the California coast. The three United States species are feeders on Chenopodiaceae and inhabit alkaline or saltmarsh regions. In the western United States they are called "alkali bugs."

They are all considerably larger than the species of *Monoxia*, ranging from 6 to 9 mm. All are dull brownish in color, sometimes piceous, and sometimes the elytra are marked by two rather indefinite vittae, one lateral and the other subsutural. The head is densely punctate and more or less pubescent above, with the median line not always well defined. The lower front is not produced, but broad, flat, and glabrous. The antennae are not half as long as the body, with the third joint longer than the fourth, the fourth longer than the fifth, and the remainder approximately the same length, and longer than broad. The prothorax is not twice as wide as long, and the sides are only slightly rounded, not at all angulate, and are narrowed anteriorly. The basal angles are not prominent and are without nodules. The disc is somewhat uneven, with a small depression in the middle and one on either side, not nearly as marked as in *Galerucella* or *Monoxia*, and the surface is more or less coarsely punctate and nearly glabrous. The elytra are elongate, with parallel sides, slightly convex, without depressions, densely punctate, and either glabrous or only moderately covered with short pubescence. The epipleura are visible nearly to the apex. The anterior coxal cavities are open. The tibiae are not sulcate, and the first tarsal joint is as long as the next two. The claw in the male has a fine tooth on the inner side, not as long as the outer, and in the female the claw is untoothed. The aedeagus is very long, slender, and flat, and because of its length lies in a somewhat bent position in the abdomen. It is quite unlike any aedeagus that I have seen in species of *Galerucella* or *Monoxia*.

KEY TO THE SPECIES OF ERYNEPHALA

1. Upper surface nearly glabrous. Mountains of Western Mexico........ ....*glabra* n. sp.
   Upper surface more or less conspicuously pubescent.................2
2. Elytra markedly wider than prothorax and covered with short, fine pubescence somewhat obscuring the punctation; prothorax usually somewhat depressed with deep coarse punctures. Inland species (Federal District, Mexico; Texas; Great Plains; Rocky Mountains to Manitoba) ....*puncticollis* (Say)
   Elytra not much wider than prothorax; pubescence only moderately dense with punctation not at all obscured; prothorax not depressed and more shallowly punctate. Maritime species........................3
3. Pubescence on head and elytra distinct and rather long; frontal tubercles on head well marked. Pacific coast.....................*morosa* (Lec.)
   Pubescence on head and elytra short, not at all conspicuous; frontal tubercles on head indistinctly marked. Atlantic coast...*maritima* (Lec.)

ERYNEPHALA PUNCTICOLLIS (Say)

Galeruca puncticollis Say, Journ. Acad. Nat. Sci. Phila., **3**: 458. 1824.
Galeruca erosa LeConte, Trans. Am. Ent. Soc., **13**: 28. 1885.
Monoxia puncticollis Horn, Trans. Am. Ent. Soc., **20**: 83. 1893, in part.

As already stated, Horn included under Say's name *puncticollis* LeConte's three species, *G. maritima, morosa* and *erosa.* It is by no means certain that Say made a mistake in describing *puncticollis* as three-twentieths of an inch long, or that he did not have in hand a beetle quite different from any of LeConte's species and about half their size. However, since no other species appears to answer his description, I am unwilling to change the name of this well known and economically important beetle. Of the three species described by LeConte, Say's name can be applied only to the inland species, *G. erosa,* since Say wrote that *puncticollis* was taken on the Mississippi and on the Arkansas near the mountains.

LeConte described *G. erosa* as "dull yellow, finely pubescent. Head strongly, densely punctured, prothorax cribrate. Elytra finely, very densely punctured, outer joints of antennae and the tarsi fuscous. Length 8 mm. Utah. Quite different from our other species (*maritima* and *morosa*) by the coarsely sculptured thorax which has also four shallow discoidal impressions. The third joint of the antennae is a little longer than the fourth, whereby it differs from Trirhabda, which it greatly resembles in form."

In the LeConte collection are three specimens, all labelled Utah. The one bearing the label *G. erosa* is a female and the other two are males. These correspond with LeConte's description and are without doubt the specimens he had before him in describing the species. The head is pale, with short appressed yellow pubescence, not entirely obscuring the punctation below; the lower front is broad, smooth and shining, and is without the wide depression below the antennal base found in *morosa.* The first four basal joints of the antennae are pale and the rest darker brown. The prothorax is narrowed anteriorly and greatly depressed, with large, coarse punctures, each puncture bearing a short, pale yellow hair. The elytra are wider in proportion to the prothorax than in either *morosa* or *maritima,* and covered with a fine, dense, yellow pubescence, and the punctation is not as coarse as in *morosa.* The body beneath is pale.

This is the most distinctive of the three United States species of *Erynephala.* It is the largest (sometimes as much as 9 mm.), has the densest elytral pubescence, and the most coarsely punctate and depressed prothorax. The aedeagus, resembling that of *morosa* in its tip, differs from both *morosa* and *maritima* in having the opening on the dorsal side situated farther from the tip. As in the other two northern species, there is great variation in color, specimens varying from pale to piceous. Usually the lower front of the head, prothorax and margin of the elytra are pale in the darkest specimens. The elytra in the majority of the specimens examined are yellowish brown, but occasionally they are vittate.

Distribution: Texas (Del Rio, El Paso, Barstow, New Castle, Pecos), Kansas (Meade Co., Clark Co., Wichita), Nebraska (Lincoln), New Mexico (Hagerman, Albuquerque, Artesia, Maxwell), Utah (Provo, Bear River, Thatcher, Garfield, Saltair, Salt Lake), Colorado (Colorado Springs, Rocky Ford, Ft. Collins, Longmont, Greeley), Idaho (Sugar City), Montana (Billings), Manitoba (Winnipeg, Stonewall, Baldwin).

Erynephala morosa (LeConte)

Galeruca morosa LeConte, Rept. Pacific Survey, p. 70, 1857.
Monoxia puncticollis Horn, Trans. Am. Ent. Soc., **20**: 83. 1893, in part.

LeConte's Latin description of *G. morosa* may be translated thus: elongate, piceous, lightly covered with cinereous pubescence, the head finely

and densely punctate, with two smooth callosities over the antennal bases, the prothorax strongly punctate, uneven, with a deep median and two more indefinite lateral foveae; the elytra a little wider than the prothorax, convex, densely and not finely punctate, the suture elevated, flat towards the scutellum; length .25 inch. The description is founded on a single specimen collected in a salt marsh at San Francisco. LeConte states that it resembles a black individual of *G. maritima*, but differs from the eastern species by having the prothorax less flattened in front and less rounded at the sides, and the hind angles not flattened, the elytra more coarsely punctured, and the pubescence longer and nearly white.

In the LeConte collection is the specimen from which LeConte drew up his description, bearing the label *G. morosa* and also *San Fr.* and a round gilt label. It is a male and entirely dark except for the reddish brown mouthparts. The head is without a deep median impression and has two well marked frontal tubercles over the antennal bases. There is also a pronounced depression directly below the antennal base, such as does not occur in either *maritima* or *puncticollis*. The head above is densely, shallowly and coarsely punctate with long white pubescence, longer than in *maritima*. The antennae are entirely dark. The prothorax has nearly straight sides, is slightly convex with a small median depression and two lateral ones, and is shiny and covered with coarse, shallow, sometimes confluent punctures, not so dense in the middle. There is a slight inconspicuous pubescence on the sides. The elytral humeri, as in *maritima*, are not prominent, and the depression within is very slight. The elytra, not much wider than the prothorax, are shiny and have dense, coarse punctation and a white and not very conspicuous but long pubescence, slightly longer and more erect than in *maritima*.

LeConte points out plainly the differences between *morosa* and *maritima*. His statement that the hind angles of the prothorax of *morosa* are less flattened than in *maritima* does not hold in all cases, but generally the prothorax of *morosa* is not so depressed as that of *puncticollis*. *Morosa* differs from both *maritima* and *puncticollis* by the deep depression below the antennal bases on the lower front, as well as by the differently shaped aedeagus. It differs from *puncticollis* by its smaller size, less deeply punctate and depressed prothorax, less pronounced humeri, with the elytra not as wide in proportion to the prothorax as in *puncticollis* and longer white pubescence, in contrast with the short, yellowish pubescence of *puncticollis*. Like both *maritima* and *puncticollis*, *morosa* has several color forms. It may be pale, or the elytra may be vittate.

A. T. McClay writes that he has always collected this species in the salt marshes along the California coast.

Distribution: California (Lake Merritt, Alameda Co.; Millbrae, Los Angeles Co., Oakland, San Diego, Seal Beach).

Erynephala maritima (LeConte)

Galeruca maritima LeConte, Proc. Ac. Nat. Sci. Phila., **17**: 218. 1865.
Monoxia puncticollis Horn, Trans. Am. Ent. Soc., **20**: 83. 1893, in part.

LeConte's Latin description of *G. maritima* may be translated thus: elongate, testaceous, fuscous or black; head coarsely punctate, prothorax short, narrowed anteriorly, with broadly rounded sides and not at all prominent angles, at base on either side obliquely subtruncate; the disc somewhat convex, strongly punctate, shortly canaliculate, and on either side vaguely foveate; the posterior angles flattened and obtuse; the elytra densely

and rather finely punctate and covered with short, not dense, pale pubescence. Length .30 inch. There are color varieties in which the prothorax is partly testaceous and the elytra black with the margin and suture pale. No type locality is given, but LeConte states that the species is abundant on the seacoast from New York to Florida.

In the LeConte collection the specimen bearing the label *G. maritima* has also a round bright red label indicating the locality as the Gulf states. It is a mutilated male specimen without eyes, with only a portion of one antenna, and lacking two legs and part of a third. Except for the yellowish brown labrum it is entirely dark. The head is not at all conspicuously pubescent, in contrast with the long white pubescence of *morosa,* and is coarsely and confluently but shallowly punctate, not as densely punctate as in *morosa* and *puncticollis.* The antenna, of which only the first six joints remain, is dark. The prothorax is not depressed except for a faint median anterior spot and two faint lateral impressions and flattened hind angles, and has only slightly arcuate sides. It is shining and with scattered coarse and rugose punctation, but is not as densely punctate as in *morosa* nor excavated with deep coarse punctures as in *puncticollis,* and is nearly smooth in the middle. There is little trace of pubescence. The elytral humeri are not prominent, as they are in *puncticollis,* and there is only a slight trace of intrahumeral depression. The punctation is dense, coarse and distinct, but not as coarse as in *morosa,* and there is rather sparse short pubescence, in contrast to the long pubescence of *morosa* and the thick, fine pubescence of *puncticollis.* Besides this specimen, there are eight others, four males and four females, labeled "Del." All are somewhat paler, some yellow brown without vittae, others with entirely dark elytra and particolored prothorax, others vittate.

This species is distinguished from *morosa* by the less conspicuous and shorter pubescence, the more finely punctate elytra, the distinctly flattened hind angles of the prothorax (see notes on *morosa*), and the quite differently shaped tip of the aedeagus. It is distinguished from *puncticollis* by its generally smaller size, less coarsely and deeply punctate and less depressed prothorax, less prominent elytral humeri, more sparsely pubescent elytra, and the differently shaped tip of the aedeagus.

Some specimens from Florida and Texas, possibly representing *M. puncticollis* var. *texana* Schaeffer[3] are usually pale with brown elytral vittae, and show a more pronounced swelling near the tip of the aedeagus than is found in the northern specimens. Often in the northern specimens there is a one-sided swelling near the tip, so that this variation in the southern specimens seems to be only a matter of degree. The beetles do not present any other structural differences.

E. maritima is not known to be injurious to beets. It is found only in the salt marshes on the eastern coast feeding on *Salicornia, Dondia,* and *Salsola,* although in breeding cages I have reared it with no difficulty from egg to adult on beet leaves.

Distribution: Nova Scotia (Halifax), Maine, New Hampshire (Rye Beach), Massachusetts (Ipswich, Marblehead, Wollaston, North Cohasset, Cambridge), Connecticut (Milford, Lyme), New York (Long Island, New York City, Coney Island), New Jersey (Boonton, Avalon, Longport), Maryland (Ocean City), Virginia (Ft. Monroe, Virginia Beach, Wacha-

[3] Schaeffer, Can. Ent., **64** (10): 237. 1932. According to Schaeffer this variety is more closely related to *maritima* than to *morosa* or to "typical *puncticollis.*" It would appear that he regards LeConte's species *morosa* and *maritima,* which he calls "forms," equal in rank with his variety *texana.*

preague), South Carolina (Charleston), Georgia, Florida (Sand Point), Louisiana (Cameron), Texas (Corpus Christi, Brownsville, Galveston), Jamaica (Kingston, Liguana Plain). Two specimens labeled *Kansas* are probably mislabeled.

Erynephala glabra, n. sp.

In size, shape and coloring similar to *E. maritima,* but nearly glabrous on upper surface. Head reddish brown deepening to darker brown on occiput, coarsely and confluently punctate on upper half with a slight trace of fine pubescence. Tubercles not pronounced and depression below antennal base not marked. Antennae reddish brown and like the other species. Prothorax not twice as wide as long, narrowed anteriorly and with slightly arcuate sides; disc with trace of central and two lateral depressions, hind angles not as distinctly flattened as in *erosa* or *maritima;* punctation coarse and scattered, slightly more distinct than in *maritima;* only a slight trace of pubescence visible under high magnification; color deep reddish brown. Scutellum pubescent. Elytra with humeri no more developed than in *maritima* and *morosa,* densely and coarsely punctate, nearly glabrous excepting a slight trace of pubescence near lateral margin which disappears at apical angle; reddish brown with two darker vittae, one near suture, the other lateral, these broadening and coalescing at apex. Body beneath dark brown deepening to piceous on metasternum and first abdominal segments, lightly pubescent. Length 6.5 mm; width 3 mm.

Type: male in Bowditch collection, Museum of Comparative Zoology, Cambridge, Mass.

Type locality: Sierra de Durango, Mexico.

Remarks: This species from the mountains of western Mexico is very similar to the eastern maritime species. The only external differences between the two are the slightly deeper punctation and the nearly glabrous upper surface of the Mexican species. All the other species of the genus have distinctly pubescent elytra. The aedeagus, too, is different, having a tip similar to the eastern species, but being much wider behind the tip.

ENTOMOLOGY.—*Some new leafhoppers related to* Thamnotettix.[1]

E. D. Ball, University of Arizona, Tucson, Arizona.

The writer is working on the tree and shrub inhabiting division of the old genus *Thamnotettix* and has recently divided the group into a number of genera. As there are requests for determinations in some of these divisions the following species are described.

Gloridonus spatulatus Ball n. sp.

Resembling *gloriosus,* smaller, golden with less green on the clavus. The female segment with a narrower and shorter notch. Length ♀ 5.5. mm.

Vertex shorter and more obtusely angled than in *gloriosus,* scarcely half longer on middle than against eye, female segment long, rounding posteriorly with a slightly wedge shaped notch reaching one third of the way to the black marked base. Male plates longer and roundingly narrowing, almost oval instead of very broad and almost truncate as in *gloriosus.* The finger like tips curved up around the tips of the smaller and shorter styles.

[1] Received July 11, 1936.

Pygofers longer than the plates with their apices extending as white spatulate tips. These tips much exceeded by a pair of long black spines that lay alongside the anal tube. In *gloriosus* the pygofers are much shorter and blunter and do not equal the plates while the spines are short and curved.

Holotype[2] ♀ and three paratypes Riverside, California, June 10, 1908, allotype ♂ and five paratypes Ontario, California, June 12, 1908, all collected by the writer, and six paratypes Mint Canyon, California, June 7, 1935, taken by P. W. Oman and returned to him.

Allygianus clathratus Ball n. sp.

The male resembling a small and slender *gutturosus*, the female a large golden *limbatus* Van D., both sexes heavily reticulate. Length ♀ 7 mm.; ♂ 5.5 mm.

Vertex resembling that in *limbatus*, only slightly more than a right angle, almost as long as its basal width instead of very obtuse and nearly twice wider than long as in *gutturosus*. Elytra very long, parallel margined, not appressed, venation even more heavily reticulate than in *gutturosus*, several cross nervures between the sectors and the central anteapical, constricted and several times divided. The female uniform pale cinnamon, almost golden, the male smoky brown with definite arcs on front and a broken crescent above. A pair of dashes anteriorly and a pair of dots on the median line of vertex, four spots on disc, a broken line on pronotum. The nervures in both sexes broadly white.

Holotype ♂ allotype ♀ and seven paratypes Pine Valley, July 6, 1931, and two Beaumont Aug. 1, 1912. All taken by the writer in southern California.

Pasadenus chicanus Ball n. sp.

Resembling *pasadenus* Ball, bigger, broader, with widely flaring elytra and semi-circular male plates. Length ♀ 7 mm.

Vertex wider than in *pasadenus* but equally pointed and elytra longer, broader, with shorter apical cells. Color similar, the ivory saddle broader, the disc of the pronotum light brown with the anterior margin bearing an irregular row of black dots interrupted in the middle with yellow. Female segment with a quadrangular notch twice as wide as in depth, bordered by a black line while in *pasadenus* the notch only half as wide and is set off by a black area to the base. Male plates short, together semicircular with recurved finger like tips, pygofer hooks large turned down with the curved tips almost touching the plates. In *pasadenus* the male plates are twice as long, narrowing to almost truncate tips while the pygofer spines are long, slender, curved outward and upward, and extend well beyond the plates.

Holotype ♀ allotype ♂ Chico, California, Aug. 11, 1912, and one paratype male, Big Bar, California, July 24, 1912, all taken by the writer, 4 paratypes Redding, California, June 28, 1935, and eight Paynes Creek, California, June 27, 1935, all taken by P. W. Oman and returned to him.

Pasadenus margaritae Ball n. sp.

Resembling *pasadenus* but much paler, the brown band reduced. Male plates long, spatulate. Length ♀ 5.5 mm.

Structure of *pasadenus* nearly, more reticulations on the posterior half of corium. Vertex and face creamy shading to straw color below. Pronotum pale brown, subhyaline, the anterior submargin with irregular brown dots

[2] Types in the author's collection unless otherwise indicated.

broken on the median line. Elytra with the ivory saddle of *pasadenus* very faintly margined with brown, a definite apical band. Female segment scarcely emarginate but with a broad black median stripe. Male plates long spatulate, three times the length of the valve, their apices turned up into chitinized hooks. Pygofer hooks just visible at the sides of the plates at about two thirds their length.

Holotype ♂ allotype ♀ and three male paratypes, Alpine, July 5, 1931, one female Pasadena, July 31, 1912, and one female Santa Margarita, August 6, 1921. All taken in California by the writer.

Doleranus atascasus Ball n. sp.

Resembling *perspicillatus* O. & B. but much longer and narrower. The head markings even more definite while the long elytra have only traces of the dark markings. Length ♀ 4 mm.

Vertex, pronotum and scutellum as in *perspicillatus* nearly with the dark markings in front and the brown ocellate spots very definite. Face longer and narrower with arcs on clypeus and dark lines around lorae. Elytra much longer and narrower, one half longer than abdomen, the anteapical and apical cells long, the central anteapical but little inflated posteriorly. The nervures on clavus milky, those on corium except the outer sector smoky widened on the cross nervures but with only faint markings in the cells. Female pygofers longer and narrower; the segment rounding and elevated posteriorly with a slightly bifid projection more than twice as long as in *perspicillatus*. The male plates with long narrow fingerlike projections stronger than in that species.

Holotype ♀ Atascasa Mts., Nov. 3, 1935, Allotype ♂ Santa Rita Mts., Apr. 5, 1931, and one female paratype Huachuca Mts., Oct. 13, 1931. All taken by the writer in the mountains of Arizona.

Doleranus kinonanus Ball n. sp.

Resembling *longulus* in form and color, shorter with a shorter head and rounding male plates. Pale cinnamon with smoky clouds behind the cross nervures. Length ♀ 4.5 mm.

Vertex obtusely conical, length less than two-thirds the width at base, shorter than in *longulus*. Pale cinnamon above and below, traces of brown arcs on the sides of the clypeus, faint indications of usual color pattern on dorsum and definite smoky clouds margining the cross nervures. Female segment but little over one half as long as in *longulus* with the posterior margin slightly angularly excavated with a definite slightly dark margined triangular projection. Male valve and plates apparently fused into a convex shield as broad as long, the tips of plates distinct and separated by a "V" shaped notch.

Holotype ♀ allotype ♂ and 16 paratypes taken by the author at Kino Bay, Sonora, Mexico, Dec. 9, 1931.

Ollarianus rubianus Ball n. sp.

Large, size of and superficial resemblance to *T. languidus* Ball, pale creamy with four black spots on vertex; elytra smoky inside of broad white, almost parallel, margins. Length ♀ 6 mm.

Vertex very short, much shorter than in *balli*, over two and one-half times wider than long, almost parallel margined, pale, with two large black spots above the ocelli and two smaller ones between, sometimes elongate; pronotum two and one-half times as long as the vertex, pale with indefinite sub-

marginal spots and obscure smoky stripes. Elytra, long flaring subhyaline, the nervures and apices smoky, the dark tergum and under wings showing through give the insect a smoky appearance with the broad flaring white costal margin in sharp contrast. Below creamy with a smoky crescent under the vertex and a few brown arcs well down on clypeus. Female segment twice as wide as long, posterior margin truncate with the angles rounding (arched so as to appear excavated), with a broad triangularly rounding median projection, male valve obtusely triangular, plates together long triangular three times the length of vale, the margins concave to the broad finger-like apices which almost equal the pygofers.

Holotype ♀ allotype ♂ and four paratypes Nov. 3, 1935, two paratypes Apr. 17, two May 15, and one May 23, 1936, all taken from the slopes of Mt. Atascasa, Arizona, by the writer.

Ollarianus bullatus Ball n. sp.

Size and form of *balli* nearly. Pale creamy, with the inner pair of spots on vertex the largest, instead of those above the ocelli as in that species, and the face of the male black. Length ♀ 4 mm.

Vertex about twice as long as wide, almost parallel margined, over two-thirds the length of the pronotum. Elytra as in *balli*, inclined to be flaring with similar venation. Female segment twice wider than long, parallel margined but elevated so as to appear slightly angularly excavated, a broad roundingly triangular median projection. Male valve very broad and short, the plates together broad, roundingly narrowing with long filamentous projections which are sometimes orange as in *strictus* Ball. Pale creamy with a slight smoky cast to the elytra, a pair of small spots above the ocelli, a large pair between these some distance back from the margin, a pair just behind the eyes, a pair on the disc of the scutellum and another pair on the margins before the apex. Any or all of these spots may be missing but the face of the male has a black or smoky cloud in all examples.

Holotype ♂ allotype ♀ and three paratypes Aug. 6, 1934, one Aug. 5, 1934, one June 8 and one June 23, 1929, all taken by the writer in the Baboquivari Mts., Arizona except the last two which were taken in the desert nearer Tucson, Arizona.

Ollarianus ollus Ball n. sp.

Form of *strictus* nearly, larger, longer and more slender than *bullatus*, with a short uniformly rounding vertex and faint markings, no black on face. Length ♀ 4.6 mm.

Vertex slightly narrower than in *bullatus* parallel margined with four fine points or none, no dark on face. Markings on pronotum and scutellum small or wanting. Elytra long and inclined to be flaring. Slightly smoky in the males with the cross nervures emphasized. Female segment more than half as long as its basal width, roundingly narrowing, the posterior margin nearly truncate with the median third roundingly produced. Male valve small triangular, plates broad, long spoon-shaped with the tips elongated equalling the pygofers, the concave portion of the margins before the tips heavily black marked.

Holotype ♂ allotype ♀ and 4 paratypes together with two nymphs taken by the writer from the east slope of the Santa Rita Mts., Arizona, Aug. 18, 1935.

Ollarianus rudiculus Ball n. sp.

Size and form of *ollus* nearly, the elytra long but not as inclined to be flaring. Pale smoky, heavily marked. Length of ♀ 5 mm.

Vertex short parallel margined, creamy with four black spots in a reversed crescent. Pronotum smoky or cinereus with a submarginal row of spots, the pair behind the eyes usually round and definite. Scutellum creamy with a smoky pattern, a pair of round black spots on disc and another pair before the apex, elytra smoky subhyaline, the nervures pale brown. Face and below pale, in dark examples a pair of dashes on the upper part of the clypeus, another pair at apex and irregular fine dots outline the arcs. The female segment, as in *ollus*, the male valve short and broad, triangularly narrowing and then produced into short, broad, divergent apices longer than the pygofers.

Holotype ♂ and allotype ♀ and one paratype taken in Bear Canyon (Labeled Tucson) March 22, 1931. Three paratypes Sabino Canyon, eight from Atascasa Mt. and two Nogales, all taken by the writer in the mountains of Arizona.

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JOURNAL
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METEOROLOGY.—*Some episodes along the meteorological highway.*[1]

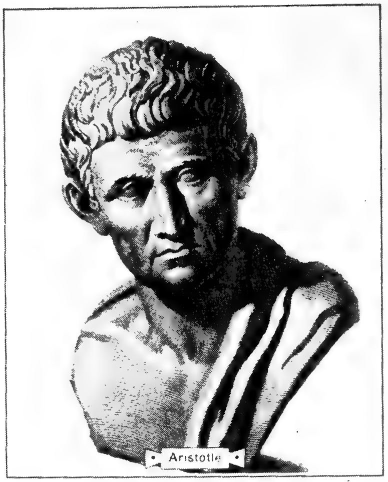
W. J. Humphreys, U. S. Weather Bureau, Washington, D. C.

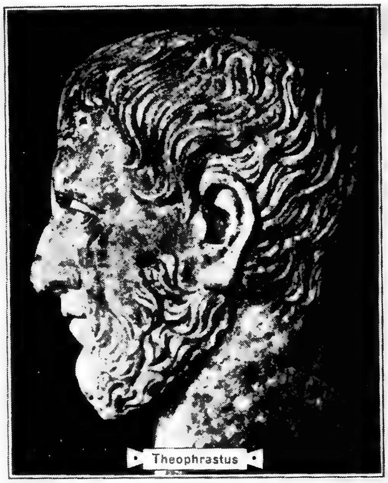
Since meteorology[2] is the science of the atmosphere or, more literally, a discourse on atmospheric phenomena, and since that in turn is mainly just talk about the weather, it follows that meteorology is at least as old as human speech, and older, too, if sign language came first. What the earliest words used in this connection were is a matter of some uncertainty, but "blizzard" and "Dunder und Blitzen," or their equivalents, would be good surmises. Any effort therefore to find a distinct beginning to meteorology would be futile, for, like Topsey, it just "growed." But in the course of this growth there have been, to date, many episodes, a few of which it may profit us briefly to consider.

Naturally ancient man, living mainly in the open and to whom therefore the state of the weather was of vital importance, soon noted many weather sequences following this or that appearance of the sky, or occurrences of other phenomena. In this way sign meteorology, or predicting the weather by local signs, had a prehistoric beginning. Furthermore it still is in abundant use, in fact nearly every one uses it more or less, official forecasters included, and many use it exclusively. Also, when properly used it is of great value. Indeed until within the memory of some people still living, that is, until the telegraph had come into practical use, no other rational means of forecasting the weather was practiced or even possible. The literature of all ages is full of its use and its success. For instance, way back in ancient times, as we are reliably informed, Elijah told Ahab to hurry and eat and get down from Mount Carmel, "for there is a sound of abundance of rain." This sound doubtless was the murmur of the

[1] An address presented before a joint meeting of the Academy and the Philosophical Society, Feb. 19, 1936. Received Feb. 19, 1936.

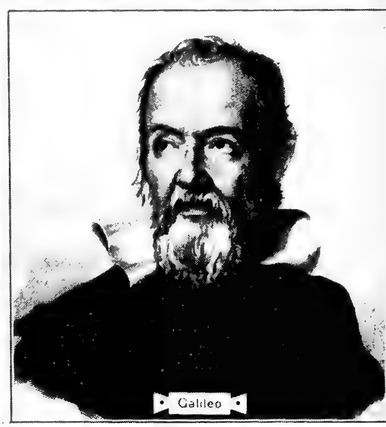
[2] The chief sources from which the material for this exceedingly brief and inadequate sketch of the history of meteorology was taken are: Hellmann's *Neudrucke*, a series of reprints of rare but important papers, and Volume I of Shaw's *Manual of meteorology*. Here and there phrases and sentences are verbatim from the original, because the ideas they convey are so well and clearly expressed that any change of their wording would, at best, be only another way of saying the same thing.


Aristotle


Theophrastus


Tower of the Winds


Francis Bacon


Galileo

forest mingled, perhaps, with the roar of the mountain. It is a good sign of rain today. It was a good sign then. "And it came to pass in the meanwhile, that the heaven was black with clouds and winds, and there was a great rain." And for ages many other physical signs of the proximate weather were in profitable use by the early Hebrews, Babylonians, ancient Greeks and, doubtless, many others besides. They correctly used many signs of the coming weather, but in the earlier days they commonly attributed the weather manifestations themselves, or at least the more important of them, to the direct interposition of some deity. In the Iliad, Homer (roughly 1000 B.C.) attributes wind and weather to the gods. Zeus has charge of thunderstorms and with them disperses the Greeks just when they have the Trojans all but defeated. In the Odyssey sometimes Poseidon commands the weather at sea, and at others Zeus. Similarly in psalm 107 it is affirmed that the Lord directly controls the weather.

On the other hand, as early as 700 B.C. Hesiod does not try to find a "first cause" but merely says: "Take heed what time thou hearest the voice of the crane from the high clouds uttering her yearly cry, which bringeth the sign for plowing and showeth forth the season of rainy weather." He also advises that it is safe (of course in his region) to go to sea as soon as the topmost leaves on the fig tree are the size of a crow's footprint. This sage comment reminds one of the American Indian's advice that it is time to plant corn when the leaves of the white oak are the size of a squirrel's ear. And so, as evidenced also in *The clouds* by Aristophanes, about 450 B.C., there early were in Greece many who attributed weather phenomena to natural causes, and who made a real beginning in rational or theoretical meteorology. Thus Anaximander of Ionia, nearly 600 years B.C., correctly defined wind as "a flowing of air"; and the great physician, Hippocrates, in the fifth century B.C., pointed out the influence of climate on health. He forcefully, if not indeed first, expressed the idea that it is the weather that moulds the life of man. Inevitably, therefore, Aristotle's work on meteorology, the first, so far as we know, around 350 B.C., and the longest lived, being without a rival for over 2,000 years, is in great measure but a compilation of knowledge and beliefs on that subject current in his day. This work is systematically arranged. Recorded facts and common knowledge are given. Other people's theories are stated, then refuted and replaced by speculations of his own. In short, it might easily be mistaken for a modern work on this subject. He says, among other things, that "everything warm tends naturally to rise." Most modern writers

say "warm air ascends and cold air comes in to take its place." Both statements are wrong but Aristotle's is the less objectionable of the two. He says also that the winds commonly are from the north or the south, and that the former are cold because they come from cold regions and the latter warm because of the high temperature of their place of origin. In this he was right, and also talking air-mass analysis, though he did not give it the benefit of any specific name.

The rational theories of Aristotle, however, had little practical use because then, as now, people in general were far more desirous of having accurate knowledge of the coming weather than an understanding of its causes. Hence, while weather science was neglected weather rules were compiled—good ones of old, and with them a vast number of new ones of doubtful value. Theophrastus, for instance, about 300 B.C. gives in his compilation 80 different signs of rain, 45 of wind, 50 of storm, 24 of fair weather, and 7 of the weather for a year or more. Some of these signs were, and are, good. What could be truer than this one? "When there is fog there is little or no rain." Many have only a moderate value while still others are but little if any better than a guess. One of his long-range forecast rules is fair, and to this day there is none better, namely: "Whenever there is much snow a fruitful season generally follows." There are good reasons for this. The snow covering prevents alternate freezing and thawing, so injurious to fall sown grain; provides, slowly, much soil moisture; and delays budding and flowering until killing frosts are unlikely to occur.

About 270 B.C. Aratus put the current weather lore in poetic form, which helped to diffuse it and to preserve it, but he added nothing to the knowledge of meteorology. Indeed but little was added to the meteorology of Aristotle and Theophrastus for 2000 years, though the work of the latter, or, more commonly, fragments of it, appeared in many places; among others in The Georgics of Virgil, first century A.D., where we have, all but direct from Theophrastus: "Straightway when gales are gathering, either the seaways begin to shudder and heave, and a dry roaring to be heard on the mountain heights, or the far-echoing beaches to stir, and a rustling swell through the woodland." Here again we have repeated that old, old allusion to the murmur of the forest and the roar of the mountain.

For many centuries after this early period, or, more exactly, during the 2000 years from Aristotle to Torricelli, meteorology advanced hardly at all. In fact it rather retrograded for during this time there were added to the physical signs of the coming weather, compiled by

Theophrastus, a lot of absurdities about the moon and the planets, and saints days—a curious mixture of silliness and sanctity, astrology and religion. Astrology goes back fully 5,000 years, to early Babylonian culture. From Babylon it passed to Greece in the 4th century B.C., and from Greece to the rest of Europe, largely by way of Rome. The movements of the constellations were a sure guide to seed time and harvest, and the general run of the weather. Various types of weather, and weather changes, previously believed to be under the direct control of the gods, were now attributed to the changing moon and wandering planets, that is, to the visible and well-known, but mysterious objects that bore the names of the gods.

When and how predicting the weather by saints days got started are not recorded. However, for centuries dates were fixed largely in terms of saint-days, just as we still count from Christmas, New Years, and many others. Also, any unusual weather during a great occasion was likely to be remembered, and if that date happened to be the "day" of a generally known saint, there was a chance for the saying to get started that on that saint's day the weather would be thus and so; or that the weather on his day controlled the weather for forty days thereafter, or was related in some other way to the coming weather, and once such a statement got started it was likely to keep going and gaining in confidence as its origin in a mere coincidence was forgotten.

The efforts of Aristotle and other Greek philosophers to explain weather phenomena as the consequences of physical causes was soon forgotten, and the far easier one adopted of leaving them all to the gods, or their wandering namesakes, the planets. And this faith remained fixed in all minds until gradually dispelled by a growing knowledge of physics. At last, about 1850, came proof of the conservation of energy and with it the eternal banishment of all hope of achieving perpetual motion, or forecasting the weather by the phases of the moon or positions of the planets.

The forecasts of the weather based on the moon and the planets were of the long-range type, and were disseminated chiefly by calendars or almanacs, which in one form or another run back to Babylon. The age *par excellence*, however, of weather-predicting almanacs was the 16th and 17th centuries when they also carried hints on farming. After being first sellers for many years their popularity greatly waned, but during much of the 19th century there was a phenomenal return of this sort of thing in the form of the free patent-medicine almanac which foretold the weather for every day of the year, and often with-

out specification of region—the same for all, just as the nostrum advertised was equally good for every ill. Fortunately the day of this almanac also is gone.

A far different approach (rational instead of irrational) to long-range forecasting is that which is by way of weather cycles. A correct highway, crowded with many travelers variously equipped for transportation, but one along which very little progress has been made towards the important destination.

Apparently the earliest persistent belief that every so many years the course of the weather substantially repeats itself developed in Holland. This 35-year cycle is mentioned by Francis Bacon in his *Essay LVIII*, 1625, on which he comments, in substance: "Come to think of it, I have noticed much the same thing myself." Two and three-quarter centuries later, in 1890, Brückner announced the discovery of the same 35-year mean cycle with a tolerance or leeway of at least 10 years on either side, a rather liberal fraction of the entire period. In 1870 Köppen published his discovery, confirmed by others since, that the average temperature of the surface air varies slightly with the sunspot cycle, especially in the tropical and temperate latitudes. But these two are not the only weather cycles known. Something like 150, including the 12-month one and the 24-hour one, have now (1936) been found and published by "reliable" workers. Indeed cycloculture in meteorology always yields an abundant harvest, but one for which there seems to be but little demand. Even the cultivators themselves of this crop have far greater pleasure in raising it than profit in using it.

In addition to, and quite distinct from, weather forecasting by signs, which, as explained above, was the only rational kind possible until comparatively recently, certain weather measurements were made long before the beginning of the Christian era, and even some weather averages—climatology, so far as they went—were published, or, as we now would say, posted for the benefit of agriculturists, shippers and the public generally. Thus rainfall was measured in India in the 4th century B.C., and the Greeks kept more or less systematic weather records as early as the 5th century B.C. They also put up marble tablets on which were given the average winds and weather for particular dates throughout the year. The Babylonians also noted the winds and used a wind vane of eight directions made up of the four cardinal points, just as they are now expressed.

Presumably most of these observations of wind direction were taken in the simple way that nearly all of us take them today, that

is, by noting the direction of drift of fallen leaves, or other light objects, the bending of trees, the feel of the air against the body, or some other conspicuous effect. But presumably, also, some of them were inferred from the pointing of the wind vane, for it, too, like the rain gauge, considerably antedates the Christian era. In Athens, for example, the famous Tower of the Winds, constructed in the 2nd century B.C., was surmounted with a wind vane.

The rain gauge and the wind vane, however, were the only meteorological instruments until comparatively recent times. True, a thermoscope was described by Philo of Byzantium in the 3rd century B.C., but it had no scale and therefore was useless for measuring temperatures.

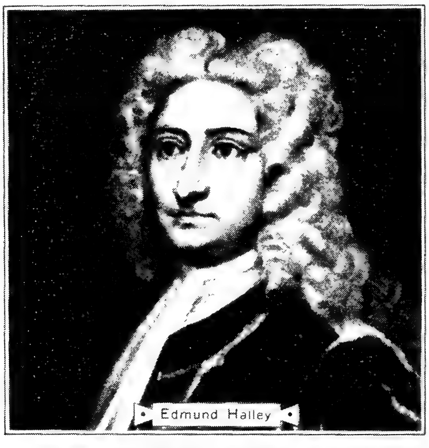
At the end of the 12th century Aristotle's meteorology came to the attention of Western Europe through Latin translations made in Spain from Arabic, not the original Greek, though this was and still is, extant. This treatise was received with such enthusiasm that courses in meteorology based on it were given, with exercises, at certain of the newly established universities. At first, and for a long while thereafter, Aristotle's work was gospel, complete and infallible, that blocked all new ideas until the effect was felt of the insistence on experiments by the French engineer, Pierre de Maricourt (Petrus Perigrinus) and his English friend, Roger Bacon.

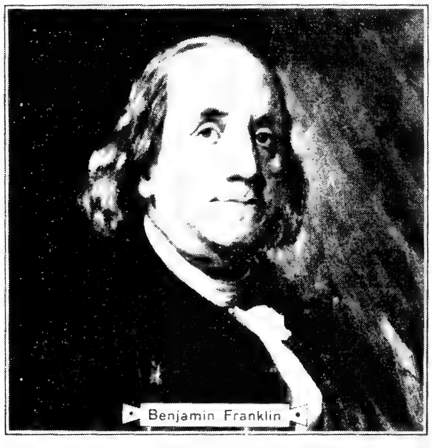
A little later William Merle, Fellow of Merton College, Oxford, kept, from 1337 to 1344, the first known day-by-day weather journal. It was continued at Driby, Lincolnshire, and published in 1891. The first records of this kind in America were kept for the years 1644–45 by the Reverend John Campanius at a fort near the present site of Wilmington, Delaware.

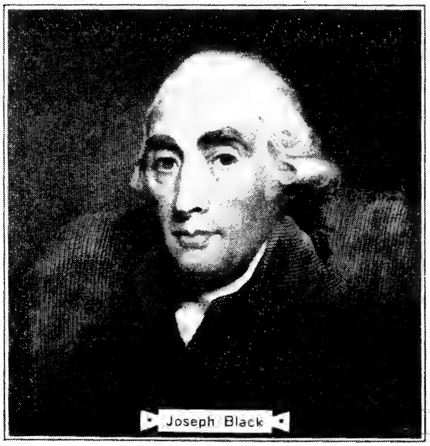
About 1590 thermoscopes were used by Galileo and others. In 1640, or thereabout, he attached a scale to the thermoscope, and thereby made of it a crude thermometer, though without fixed points. In 1701 Newton, and in 1714 Fahrenheit, proposed fixed temperature points and a divided scale and thus developed a practicable thermometer, such as ever since has been used for measuring the temperature of the air. In 1643 Torricelli, professor of mathematics in the Florentine Academy, invented the barometer, until recently the forecaster's instrument of instruments, though now not quite so all important as formerly. Five years later, in 1648 Pascal had observations made at the base and on the top of Puy-de-Dome that established the fact that the pressure of the atmosphere decreases with increase of height, from which it follows that the barometer reads higher or lower according


Torricelli


Robert Boyle


Edmund Halley


Benjamin Franklin


Joseph Black


John Dalton

as the amount of air above it is greater or less, and in proportion thereto. Only 16 years after this, in turn, Doctor Beal discovered, and in 1666 published an account of, one of the most surprising, and, even yet, not fully explained, variations of atmospheric pressure, namely, the two small maxima and two small minima of each 24 hours, when all irregular changes, such as those incident to passing storms are removed.

The first contribution to the dynamics of the atmosphere was Boyle's discovery at Oxford, in 1662, of the relation of volume to pressure, in the case of the air, namely, that, with constant temperature, the volume of a given quantity of air decreases in direct proportion to the increase of pressure.

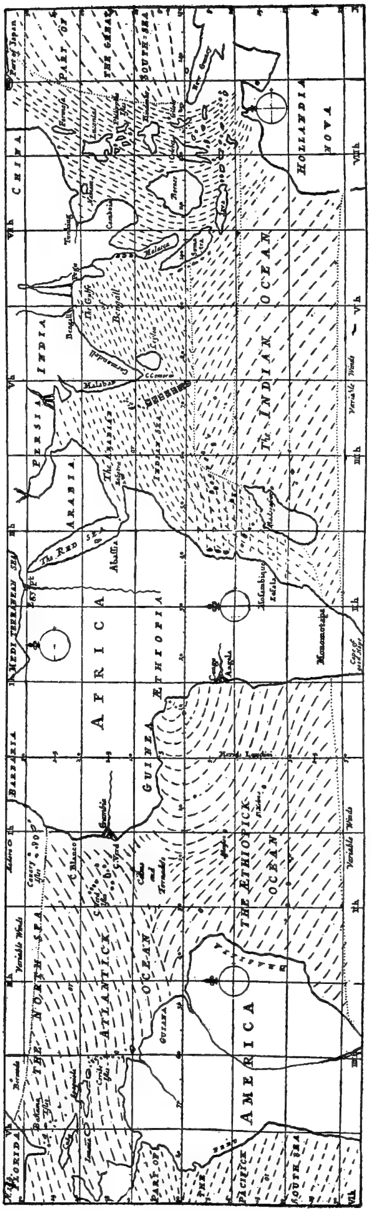
In 1686 Edmund Halley, Astronomer Royal, published in the Transactions of the Royal Society of London his famous paper on the trade winds and monsoons. Here occurs the first attempt to attribute the general circulation of the atmosphere to the distribution of temperature over the earth; and also the first map ever published of the prevailing winds of the oceans, a map that even in details is suprisingly accurate. His explanation of the trade winds was not sound in every particular, but it was a great advance in the right direction.

In discussing atmospheric circulation he says: "According to the laws of statics the air which is less rarefied or expanded by heat, and consequently more ponderous, must have a motion towards those parts where it is more rarefied and less ponderous, to bring it to an equilibrium." What a contrast there is between this statement and that stereotyped piece of silliness in so many books that says: "Hot air rises and cold air comes in to take its place"!

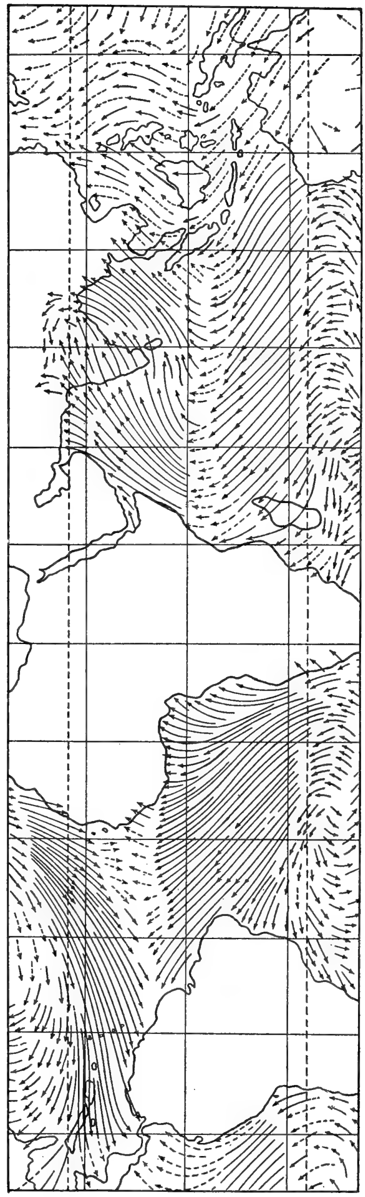
Perhaps the next outstanding contribution to meteorology was by Bouguer, a French mathematician who in 1729 published his law of absorption, or rate of decrease of the intensity of radiation as it passes through a depleting medium, such as the atmosphere.

In 1735 George Hadley explained before the Royal Society how to allow for the rotation of the earth in accounting for the trade winds. This explanation is so simple and appears so obvious and complete that it still is very widely used. Curiously enough, while it makes no allusion to the correct explanation it nevertheless was a great approach towards it.

In 1743 Benjamin Franklin, through simultaneous observations by himself in Philadelphia and a brother in Boston, established the fact that a general storm may travel in a direction opposite to that of its



Halley's Map of the Winds, 1688



Recent Map of the Winds

rain-bearing winds. In this case the winds that accompanied the rain were from the east and yet the storm itself moved in the opposite direction, towards the east. In 1749 he explained how "to determine the question, whether the clouds that contain lightning are electrified or not"; which method was followed on May 10, 1752, by Dalibard with affirmative results.

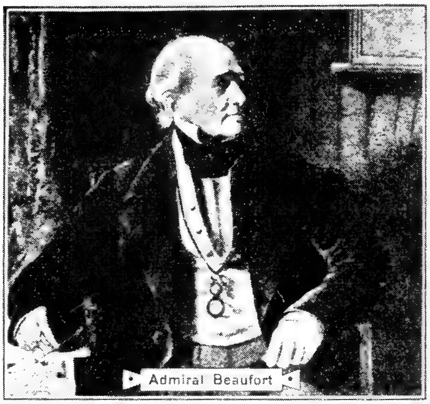
In 1756 Joseph Black, while a student of medicine in the University of Edinburgh, discovered carbon dioxide and found that it is a constituent of the atmosphere. This was the first permanent constituent of the atmosphere of nearly constant proportion to be found. That water vapor is a constituent of the air had been recognized from at least the days of Aristotle. Black also advanced the meteorologically useful concept of latent heat; meaning heat consumed without change of temperature, as in the melting of ice.

In 1772 Deluc published the meteorologically important fact that at 40°F. the density of water is greater than it is at the freezing point; important, because for this reason ice forms at the surface and not the bottom of rivers, lakes, etc. He also advanced the theory, substantially correct, that the amount of water vapor in a given space is unaffected by the presence of other gases; and gave the first correct rules for determining heights with the barometer.

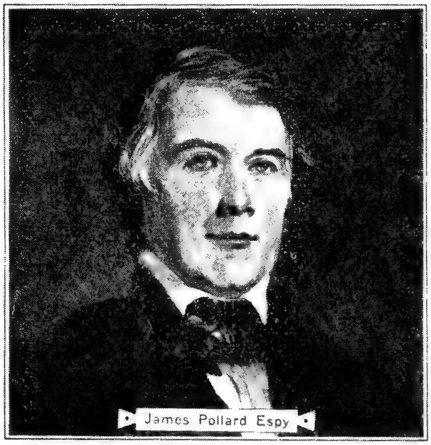
In 1783 Horace Bénédict de Saussure, a Swiss geologist, published the fact that the more humid the air the less its density, a relation more important in meteorology than it generally is supposed to be—less dense, because a molecule of water weighs less than a molecule of either oxygen or nitrogen, the main constituents of the air, and important because increase of humidity causes the air to ascend, the same as does increase of its temperature. He also gave the first elaborate discussion of the hair hygrometer.

In 1784, James Hutton, geologist, published the theory that clouds and rain are produced by the mixing of humid warm air with humid cold air. This was the first correct account of how precipitation can be produced, though it is by far the less important of the two principal methods by which it is produced. However, the principal method, cooling by expansion, could not then have been defended, even if thought of, since nothing was known of the relation of vapor density at saturation to temperature.

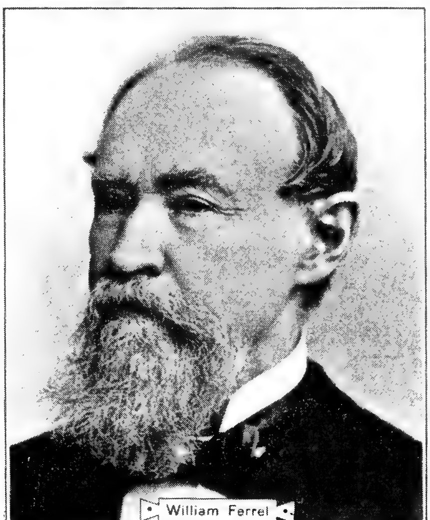
In 1787 Richard Kirwan estimated the temperatures of the different latitudes with the object of developing a theory of the winds. He was widely consulted as a weather prophet, and himself had a life of

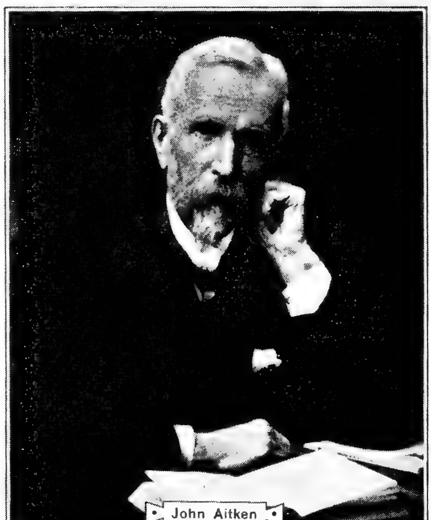

Admiral Beaufort


Luke Howard


James Pollard Espy


Matthew Fontaine Maury


William Ferrel


John Aitken

sunshine and shadow. He entered the Jesuit novitiate in 1754, but left it the next year to get married, which he did, and not only that but on the very day of the happy event also got arrested for his wife's debts. Nevertheless he was a Fellow of the Royal Society in 1780 and Copley medalist in 1782.

In 1800 John Dalton reported his experiments and observations on the heat and cold produced by the compression and rarefaction of air—facts of the utmost importance in meteorology, since cooling by expansion, incident to convection, is the chief cause of cloud formation, and the heating by compression of descending air the cause of many dry, hot winds.

In 1802 Luke Howard, chemist, as he was called in England, druggist, as we say in America, gave the chief different forms of clouds their scientific christening, which names soon came into general use and have so remained.

In 1806 Admiral Beaufort graded the winds according to their strengths as evidenced by the waves and other phenomena they produce. This grading is very important and still in use—universally at sea, and also to some extent on land.

In 1814 Charles Watts, a London physician, born in Charleston, S. C., published the correct theory of the formation of dew.

In 1841 Espy published his *Philosophy of storms* in which he urged that the general, or wide-spread, storm has a low-pressure center resulting from thermal convection in that region; that this convection is strengthened by the latent heat of condensation in the rising air; that the low pressure leads to surface inflow of air and a spiral circulation; and, finally, that the storm is carried forward by the general circulation of the atmosphere. This widely discussed, and very generally accepted, theory still holds reasonably well for the tropical cyclone, but is quite inadequate as an explanation of the usual cyclone of the middle and higher latitudes.

In 1846 the Irish astronomer and physicist, Robinson, invented one of the most familiar and useful of meteorological instruments, the hemispherical cup anemometer for measuring wind velocity. This is a striking example of an exceedingly simple instrument that works, though its theory is excessively difficult.

In 1855 Matthew Fontaine Maury published his famous work, *The physical geography of the sea,* based on a vast amount of information gathered from ships' logs on winds at sea and ocean currents. Although Maury was not the first in this field, it was the thoroughness of his work, its practical value and the abundance of his enthusiasm

that first fixed attention on the importance of marine meteorology.

The next year, 1856, saw another important contribution to meteorology, namely, William Ferrel's *Essay on the winds and the currents of the ocean.* This essay appeared in a medical journal of small circulation published at Nashville, Tenn., and thus was practically hidden from those most likely to be interested in it. However, a discerning Frenchman chanced to see it and at once brought it to the attention of mathematicians and physicists.

In 1880 John Aitken, a Scotch marine engineer, too donsie to endure the labors of his profession and yet so genuine an amateur that he just had to experiment, discovered one of the most important facts in the whole realm of meteorology, namely, that fog and cloud form at or near the saturation point only in air that contains certain foreign substances, such, for example, as excessively minute particles of sea salt. Like many other important discoveries this, also, was a rediscovery. It was first found experimentally by the French scientist, Coulier, in 1875, but buried, so far as such a subject is concerned, in a pharmaceutical journal. Shortly afterwards Coulier himself, through misinterpretation of further experiments, reversed his first conclusions, and then dropped the matter. Perhaps it was well that Aitken was unaware of Coulier's work.

The year 1880 is notable for another contribution to meteorology, the invention by Langley of the bolometer by which it is possible to determine the intensity of the solar radiation just outside the earth's atmosphere. This ingenious device later was brought to a high state of excellence by Abbot and his coworkers.

In 1899 Teisserenc de Bort discovered, with small balloons carrying self-recording apparatus, that unsuspected realm, the stratosphere. At first this discovery was not accepted, but it soon was confirmed by Assmann and many others.

During the 35 years of the 20th century, just past, the major work in theoretical meteorology has been consolidating the advances already made, filling in details and presenting the whole in such manner as to secure for it recognition as a respectable—in parts even formidable—branch of physics, which it really is, rather than as a mere interlude in elementary geography as formerly treated.

Organized meteorological observations were begun in 1654, very shortly after the invention of the barometer, when the Grand Duke Ferdinand II of Tuscany, through his chaplain and secretary, Luigi Antinori, secured the cooperation of several observers in Italy and adjacent countries, and to whom were distributed instruments and

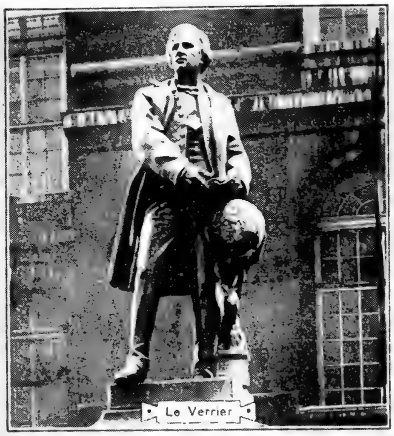
forms for maintaining daily records of the principal meteorological elements. This first work was continued for 13 years, though but few of the records have been preserved. Several similar undertakings were started during the next century in France, England and Germany, the chief of which was the international one maintained by the Meteorological Society of the Palatinate, founded at Mannheim in 1780 under the auspices of the Elector Karl Theodor. This society distributed standard instruments to its observers who were widely scattered. Their detailed observations down to 1792 were published in 12 large volumes.

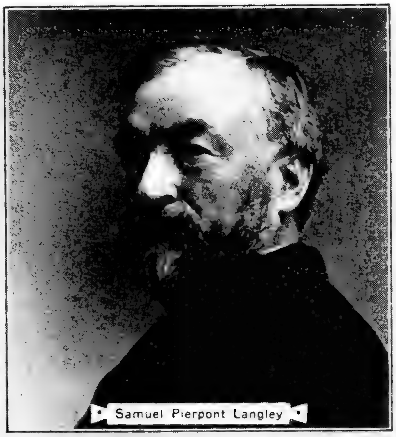
The first person to construct daily synchronous weather maps was the German physicist, H. W. Brandes, who used for this purpose the observations made by the Society of the Palatinate and some others. These charts were of Europe for 1783.

In the United States Josiah Meigs, commissioner of the General Land Office, established in 1817 a system of tridaily observations at the various land offices, and at about the same time the Surgeon General of the Army inaugurated regular weather observations at military posts throughout the country to find the influence of climate on health.

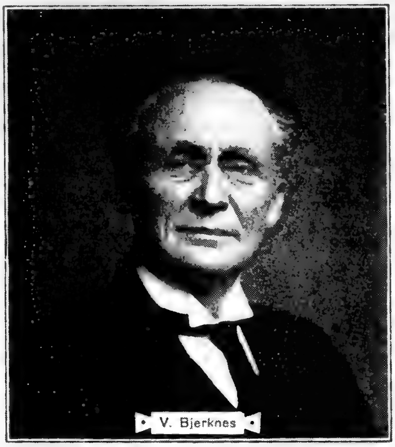
Local systems of observations were established in New York state in 1825, in Pennsylvania in 1837, and more generally by the Patent Office in 1841, and the Smithsonian Institution in 1847. Experiments in collecting weather data by telegraph, and using them in forecasting storms, were undertaken by the Smithsonian Institution in 1849, at the same time that James Glaisher, with the cooperation of the British railways, was collecting and publishing similar reports in England.

Thus the way was prepared and the time at hand for the establishment of national weather services. Only some compelling realization of their need yet was required, nor was that realization long delayed, for it came in November 1854—came as a violent storm that sank in the Black Sea many French and British vessels that were carrying invaluable stores for the allied armies in the Crimea. Immediately Le Verrier, director of the Observatory of Paris, collected information that not only showed the progress of this storm across Europe, but also demonstrated that its occurrence on the Black Sea could have been foretold so far in advance that much, at least, of the disaster easily might have been avoided. Stimulated by this clear demonstration the French Government, with the aid of other European countries, forthwith established a storm-warning system in 1855. Other


Le Verrier


Samuel Pierpont Langley


Teisserenc de Bort A. Lawrence Rotch


V. Bjerknes


J. Bjerknes H. U. Sverdrup C. Stormer Helland-Hansen

countries quickly followed with similar nationally supported weather services. That of the United States was established in 1870.

Each of these services has many functions, the most widely known of which, though there are several others of great importance, is that of forecasting the coming weather, not for months ahead, but, as a rule, for only a few hours (as commonly for the aviator) to a day or two. To this end various methods, at least in details, have been evolved, and some forecasters have been amazingly successful. They forecast from the average map with the same seeming intuition (seeming to those who are not experienced in such work) that carries the master chess player to certain victory over a novice.

Basically, however, every one used mainly the same data plotted in the same general way, and hence the same sort of weather maps. These showed the distribution of atmospheric pressure, air temperature, state of the weather, rate and sense of pressure change, kinds and amounts of clouds and the directions of their movements, all as simultaneously observed at an agreed-upon time. In some cases other weather factors, such as humidity, also were supplied. The forecaster therefore used maps crowded with a great wealth of detail, and yet not until 1918 did any weather map show explicit information about the very things which long had been known to be the carriers of weather and the localizers of its changes, namely, moving discrete masses of air from different sources, and the loci of their fronts at a given time. Maps that contained this information were first used in practical weather forecasting by J. Bjerknes and H. Solberg, two young Norwegian meteorologists—used because the World War made it impossible for them to obtain the usual amount of the orthodox pressure, temperature and other weather data, over the Norwegian Sea and adjacent regions. This attempt was surprisingly successful, especially for short range forecasts, and now has become widely studied and more or less adopted in many countries. Conservatism, however, is the watchword, for the wise thing to do is to blend together, so far as possible, the good of all methods, or, more exactly, the better features of all modifications of the classical method, modifications that have come largely from the knowledge the aeroplane brings us every day and every hour of the state and condition of the free air over many great regions.

As implied above, the basic concept of moving discrete masses of air that largely retain for long distances the temperatures and other conditions appropriate to the regions from which they come, was so early noted that its origin cannot be traced. Even Homer recognized

it, as did also Aristotle and many others. Here, for instance, is a quotation of which an up-to-date polar-front enthusiast well might be proud; it is in explanation of the squall storm and reads as follows: "Here the colder polar current finds in its way an equatorial current nearly saturated with vapor. As it proceeds, shoving like a wedge over the surface beneath the equatorial current, it forces it upward. The equatorial current, growing colder from below and above, commences to condense its vapor, to evolve heat, and increase, therefore, its upward motion by its own action." This (and there is a lot more equally good) did not first appear in the latest work on the subject, but in the New York *Daily Times* of November 18, 1852, and again in Appendix A to a fair sized book by William Blasius published in 1875.

After this came the mathematical basis for wind movements and storm genesis by Helmholtz, Margules and V. Bjerknes, now hidden by the great and growing superstructures of everyday practical meteorology. And judging from the keen and active interest everywhere shown in the subject in all countries it is safe to assume that there is more worth-while history of meteorology in the next few decades than has been produced by all the centuries of the past.

BOTANY.—Lepidonia, *a new genus of Vernonieae, with a nomenclatorial note on the name* Leiboldia.[1] S. F. BLAKE, Bureau of Plant Industry.

In 1891 the late J. M. Coulter described *Vernonia salvinae* var. *canescens*, based on *von Tuerckheim* 583 from Coban, Guatemala, distinguishing it from *V. salvinae* Hemsl. by the "dense pannose tomentum" of the lower leaf surface. In his revision of North American Vernonieae, in 1906, Gleason placed Coulter's variety as a doubtful synonym of the rare and little known *Leiboldia mexicana* (Less.) Gleason (*Vernonia mexicana* Less.) because of its agreement in leaf pubescence, stating that he had seen no specimen of it. In his later treatment of the same tribe in the North American Flora, Gleason, although still separating *Leiboldia* from *Vernonia* by the same key character as in his earlier treatment, put *Leiboldia salvinae* and *L. mexicana* back in *Vernonia* and retained *V. salvinae canescens* Coulter as a doubtful synonym of *V. mexicana*.

In the United States National Herbarium there is a sheet of the type collection of *Vernonia salvinae* var. *canescens* Coulter from the

[1] Received August 15, 1936.

Fig. 1.—*Lepidonia paleata* Blake. *a*, branch, ×1/2; *b*, corolla, ×2; *c*, two anthers, ×5; *d*, style ×5; *e*, immature achene, ×5; *f*, part of pappus bristle, ×10; *g*, pale, ×3; *h*, *i*, and *j*, outermost, middle, and innermost phyllaries, ×3.

herbarium of the late Capt. John Donnell Smith. Examination of this specimen shows that the plant is not only quite distinct specifically from *V. salvinae* as well as (from description) *V. mexicana* Less., but that it represents an undescribed genus of Vernonieae, nearly related to *Vernonia* but distinguished at once by its paleaceous receptacle. Coulter overlooked the remarkable nature of the receptacle, but it was noticed by Capt. Smith, who has written on the sheet: "*V. Salvinae* aff., receptacle paleaceous as in figure of that species; but leaves canescent beneath, and involucre apparently different." Capt. Smith's reason for assimilating it to *V. salvinae* in respect to the receptacle was that in the original illustration of that species, although the receptacle is shown as naked in Fig. 1, in the explanation of the plate Fig. 2, which represents one of the inner phyllaries, is labeled "a palet." The error is corrected in a letter to Smith from W. B. Hemsley which is attached to the sheet.

Lepidonia Blake, gen. nov.

Suffrutescens (?); caulis densissime pilosus; folia alterna magna obovata petiolata penninervia serrulata supra viridia pilosa subtus dense canescenti-tomentosa, nervis rufidulo-pilosis; capitula homogama discoidea majuscula ad apicem caulis pauca, pedunculis foliis brevioribus solitariis 1–2-cephalis. Involucri hemispherici valde gradati ca. 8-seriati phyllaria exteriora (ca. 5-seriata) parva ovata infra indurata pallida 1-costata appendice brevi herbacea lanceolata v. ovata plus minusve squarrosa praedita, interiora lineari-oblonga crasse chartacea subenervia sub appendice tenuiore subscariosa ovata apiculata 1–3-nervia paullum angustata. Receptaculum latum rotundatum, paleis linearibus stramineis persistentibus planiusculis ubique onustum. Flores omnes hermaphroditi fertiles, corollis infundibuliformibus alte 5-dentatis. Stamina 5, basi alte sagittata auriculis obtusis, apice appendice ovata munita. Styli infra ramos hispiduli rami lineari-subulati dorso hispiduli. Achenia (immatura) obovoidea valde 5–6-costato-angulata glabra truncata, apice paullum incrassata et 5–6-nodosa. Pappi decidui setae plurimae pluriseriatae inaequales gradatae conformes subcapillares hispidulo-barbellatae.—Species typica *L. paleata* (*Vernonia salvinae* var. *canescens* Coult.)

Lepidonia paleata Blake, nom. nov.

Vernonia salvinae var. *canescens* Coult. Bot. Gaz. **16**: 95. 1891.

Caulis (vel ramus) dense sublanato-pilosus pilis brunneis; petioli 1–2 cm longi, sicut caulis pubescentes; folia obovata 16–21.5 cm longa 6–7.5 cm lata breviter acuminata basi longe cuneata mucronulato-serrulata supra viridia subdense breviter pilosa pilis tenuibus basi paullum incrassatis aliis paucioribus longioribus multiloculatis intermixtis glabrescentia, subtus tenuiter sed persistenter canescenti-tomentosa in pagina et densius in venis majoribus rufidulo-pilosa submembranacea penninervia, nervis ca. 10-jugis in ambabus paginis prominulis; pedunculi terminales et subterminales ut videtur extra-axillares sicut caulis pubescentes 4.5–6 cm longi nudi v.1-

foliati 1–2-cephali; involucri 7–8 mm alti 1.3–1.5 cm lati (in sicc.) phyllaria exteriora in basi indurata margine breviter pilosulo excepto subglabra, in appendice foliacea basem subaequante v. multo breviore dense pilosula, interiora (1.3–1.8 mm lata) in appendice sessili-glandulosa et obscure ciliolata ceterum glabra; corollae 10.5–12 mm longae glanduloso-adspersae, tubo cylindrico sursum infundibuliformi 5.8–7.5 mm longo, faucibus ca. 1 mm longis, dentibus lineari-lanceolatis apice recurvatis 3.5–3.8 mm longis; paleae receptaculi lineari-lanceolatae acuminatae rigidae stramineae obscure ciliolatae sparse strigillosae 5–7.5 mm longae; achenea valde immatura olivacea glabra 1.8 mm longa; setae pappi stramineae 1.5–3 mm longae.

GUATEMALA: In very deep shady woods ("in tiefsten Waldesschatten"), near Coban, alt. 1460 m., March 1881, *von Tuerckheim* 583 (type collection: U. S. Nat. Herb. no. 1,401,303).

As the name *canescens* is already in use in *Vernonia,* it seems desirable, in raising this plant to specific rank, to give it a new and distinctive name. The generic name is derived from λεπίς, *scale,* and *Vernonia.*

Until recently only two genera of Vernonieae with truly paleaceous receptacle had been described—*Heterocoma,* of Brazil, and *Bolanosa,* of Mexico,—although alveolate, fimbrillate, or setiferous receptacles are found in several genera. From both these *Lepidonia* differs decidedly in pappus as well as in other features. Its closest relationship, as shown by resemblance in habit, foliage, involucre, achene, pappus, and floral details, is with the small group of *Vernonia* centering around *V. salvinae,* from which it differs technically only in its paleaceous receptacle. This feature is such an unusual and significant one in the Vernonieae that it seems necessary to regard it as of generic value. The genus is to be inserted in the system next to *Vernonia.*

In Humbert's monograph on the Compositae of Madagascar two additional genera of Vernonieae with paleaceous receptacle are listed[2]—one *Diaphractanthus,* a new monotypic genus, not closely related to *Vernonia,* the other *Centauropsis,* a close relative of *Vernonia* and evidently even closer to *Lepidonia. Centauropsis,* an endemic Madagascar genus of 6 species, had previously been described as with naked receptacle, but Humbert states that the receptacle is paleaceous, and separates it from *Vernonia* by this feature. Bentham and Hooker, and following them O. Hoffmann, separate it from *Vernonia* by its acuminate-subcaudate anther bases, and the same character may be used to distinguish it from the geographically remote *Lepidonia.* I have not been able to examine any material of *Centauropsis.*

In his revision of North American Vernonieae in 1906 Gleason[3] recognized four genera (*Lachnorhiza, Leiboldia, Vernonia,* and *Eremosis*) in the genus *Vernonia* as understood by most authors, and in his later treatment in the North American Flora a fifth was added (*Cyanthillium*). None of these segregates, all of which were named by earlier authors, seem worthy of

[2] Mem. Soc. Linn. Normandie **25**: 16, 17, 29. 1923.
[3] Bull. N. Y. Bot. Gard. **4**: 154. 1906.

recognition. The invalidity of *Eremosis* as a genus I discussed[4] some years ago. The other genera are all distinguished from *Vernonia* by having their "pappus-bristles in one or more series, essentially uniform in length," in contrast with the "pappus in two series, the outer of scales or bristles and much shorter than the inner" of *Vernonia*. The three alleged genera are then separated by the following key:[5]

"Leaves all basal. 4. *Lachnorhiza*.
Leaves chiefly cauline.
Stems woody; leaves densely tomentose beneath. 5. *Leiboldia*.
Stems herbaceous; leaves thinly pubescent beneath. 6. *Cyanthillium*."

The extreme inadequacy of such habital characters as these as a basis for generic segregation is obvious, whether one considers intrageneric variation in the Asteraceae in general or the genus *Vernonia* (as left by Gleason) in particular; and comparison of Gleason's full descriptions of these so-called genera brings to light no further differences of any consequence. Moreover, the single pappus character by which they are separated as a group from *Vernonia* proves to be far from constant, and does not apply to some of the plants assembled under it. The contrast between the pappus of such a *Vernonia* as *V. argyropappa* Buek—conspicuously double, the inner of subequal capillary setae, the outer of several times shorter, linear squamellae—and that of V. *piloselloides* (A. Rich.) Maza (type of *Lachnorhiza* A. Rich.)—of similar, only slightly unequal, definitely but slightly flattened setae—is significant taxonomically and would, if reasonably constant throughout the group, suffice for the separation of genera. Unfortunately the transition between these two extremes is a very gradual one. Even in *V. piloselloides*, although nearly all the bristles are nearly of the same length (some essentially capillary, some slightly but distinctly flattened, and practically all with slightly dilated tips) there are usually a few shorter outer ones to be found, half or two-thirds the length of the inner, and in one case (a single bristle) only about one-tenth the length of the inner. In this species, as in most of the species of typical *Vernonia*, the pappus is decidedly persistent, so that achenes can be withdrawn from the head by its means. In the two other segregates recognized by Gleason, *Leiboldia* and *Cyanthillium*, particularly the latter, the pappus is so fragile and so readily deciduous that it is practically impossible, even with the greatest care, to withdraw from a dried specimen an achene with all its pappus in place for study. In *Vernonia patula* (Ait.) Merrill (*Cyanthillium chinense* (Lam.) Gleason)[6] the bristles

[4] Contr. Gray Herb. **52:** 16–17. 1917.
[5] N. Amer. Fl. **33:** 47. 1922.
[6] Gleason, N. Amer. Fl. **33:** 51. 1922, cites *Conyza chinensis* Lam. as the type of *Cyanthillium* Blume and uses the name *Cyanthillium chinense* (Lam.) Gleason for the species that has generally been known as *Vernonia chinensis* (Lam.) Less. Blume (Bijdr. 889. 1826), when describing his genus, actually based it on three new species, *C. villosum*, *C. pubescens*, and *C. moluccense*, with no synonyms given. These are referred respectively by Koster (Blumea **1:** 431–435. 1935) to *Vernonia patula* var. *typica*, var. *pubescens* (Blume) Koster, and *V. moluccensis* (Blume) Miq. The type

are in part essentially capillary, in part slightly but distinctly flattened, but without sharp differentiation in this respect. They are numerous and in one head examined varied from 1.8 to 3.5 mm in length, so that, although all essentially similar, they must be decidedly graduate, despite Gleason's characterization of them as "equal."

The segregate genus *Leiboldia* is particularly interesting in this connection. In his 1906 revision, Gleason regarded the genus as consisting of 4 species: *L. salvinae* (Hemsl.) Gleason, *L. mexicana* (Less.) Gleason, *L. leiboldiana* (Sch. Bip.) Gleason, and *L. serrata* (D. Don) Gleason. All, presumably, were supposed to have the pappus characteristic of the genus as distinguished from *Vernonia*—"in 2–3 series, capillary, its bristles all equal or nearly so, at least not in two unequal series." In his 1922 treatment, however, Gleason, although retaining the genus, with the same characterization, for *L. leiboldiana* and *L. serrata*, referred *L. salvinae* and *L. mexicana* back to *Vernonia*, and described the pappus of *V. salvinae* as "pale-tawny, the bristles 5 mm long, the scales subulate, very deciduous, 0.8–1.1 mm long." He does not give a detailed description of the pappus of *V. mexicana*, but Lessing had originally characterized it as "setaceus, flavescens, multiserialis, inaequalis, linea parum longior." I have seen no material of *V. mexicana*, and am unable to distinguish, in the material examined, the two supposed species *Leiboldia leiboldiana* and *L. serrata* (for which I adopt[7] the name *V. arctioides* Less.). In this species, although the pappus is fragile, it is possible to obtain achenes with sufficient pappus in place to show its nature well enough. In *Pringle* 6085, listed under *L. leiboldiana* by Gleason in 1906, the pappus consists of numerous, white, for the most part slightly but distinctly flattened and not "capillary" bristles, and these are distinctly in two groups—the outer 2.4–5 mm long, the inner subequal, 9 mm long, and with decidedly flattened tips. No bristles really intermediate in length were observed. That is, the pappus in this species is quite as "biseriate" as in ordinary *Vernonia*, although the outer series is longer than usual and not differentiated as to breadth from the inner. As for the last point, lack of differentiation between the inner and outer series of the pappus, except in regard to length, is by no means uncommon in *Vernonia* and is particularly mentioned by Gleason in some species, for instance *V. fasciculata*, *V. marginata*, *V. tenuifolia*, and *V. corymbosa*. In *V. salvinae*, which Gleason now refers to *Vernonia*, describing the bristles as 5 mm long, the scales as

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species of Blume's genus should be cited as *Cyanthillium villosum* Blume, not as *Vernonia chinensis*. Merrill (Philipp. Journ. Sci., ser. C. Bot. **3**: 439. 1909) has shown that the valid name for the species generally called *Vernonia chinensis* (Lam.) Less. is *Vernonia patula* (Ait.) Merrill, since *Conyza chinensis* of Lamarck, on which Lessing's name was based, is different from the earlier *Conyza chinensis* L. Lamarck's species was not described as new but was ascribed to Linnaeus, and is merely a misidentification of Linnaeus' plant. Merrill attributes the name-bringing synonym *Conyza patula* to Dryander, but it seems better to follow general usage and attribute this as well as other names in Aiton's *Hortus Kewensis* to Aiton, the nominal author.

[7] In Standl. Contr. U. S. Nat. Herb. **23**: 1412. 1926.

subulate, very deciduous, 0.8–1.1 mm long, I find a pappus quite different from his description or from that just described for *V. arctioides*. In *E. W. Nelson* 3747 the pappus is pale brown, readily deciduous, and made up of very numerous, similar, capillary to distinctly flattened and often longitudinally somewhat twisted setae, and these vary very regularly in length from the innermost (7 mm) to the outermost (1 mm), without any recognizable hiatus. This agrees very closely with Lessing's description (quoted above) of the pappus in *V. mexicana*. It appears, then, that the species (*V. salvinae* and *V. mexicana*) at first included in *Leiboldia* by Gleason but later referred by him to *Vernonia* are the only ones that even approach agreement with his character of the genus, and that the species (exemplified by *Pringle* 6085) retained in the genus by him is in much closer agreement with ordinary *Vernonia*. *Vernonia lankesteri* Blake, the Costa Rican relative of *V. salvinae*, agrees closely with the latter in its pappus.

Such differences as are shown by the pappus of the plants discussed above do not seem to be of generic value. Species in different groups of the genus *Vernonia* show much variation in respect to the presence or absence of the outer pappus, and its character when present (compare the accounts of the genus in Bentham & Hooker and in Engler & Prantl). The situation was well summarized by Bentham & Hooker:[8] "Pappi exterioris absentia minime valere videtur, nam in speciebus nonnullis setae exteriores in diversis achaeniis ejusdem paniculae adsunt paucae v. omnino desunt, et in speciebus finitimis quoad copiam valde differunt, dum paucae saepius caducissimae sunt."

A note on the status of the generic name *Leiboldia* is added.

NOMENCLATORIAL NOTE ON THE NAME LEIBOLDIA

The name *Leiboldia*, although first used by Schlechtendal in 1847, was not given effective publication until Gleason's paper of 1906. Schlechtendal[9] described "*Vernonia Leiboldiana* n. sp. (s. *Leiboldia ovata*)." In his discussion of the species, on the following page, he remarked: "Species haec arcte affinis est *V. arctioidi* (*Leiboldia arctioides*) a Lessingio optime descriptae . . . " After describing the differential characters of the fruit and pappus in these two species, he added: "Hinc generis novi proposui nomen vel sectionis, naturalis modo ex tota planta hauriendae, nec modo artificiali e paucis characteribus in genere tam diversissimas formas continente petendae." The translation of this sentence offers some difficulty; but, on the assumption that the first "modo" is the adverb and not the ablative of "modus," and that "naturalis" is not an error for "naturali," it may be rendered: "Hence I have proposed the name of a new genus or section, natural only if drawn from the whole plant, not to be sought in an artificial

[8] Gen. Pl. **2**: 228. 1873.
[9] Linnaea **19**: 742. 1847.

way from a few characters in a genus containing such extremely varied forms."

Leiboldia is thus one of those half-published names which have always been a source of uncertainty and annoyance. Its printed appearances, on the pages cited, are only in synonymy, and its author's remark that he proposed it as the name of "a new genus or section" does not clarify the situation. By the "American Code" (Art. 10), under which Dr. Gleason was working on both occasions (1906 and 1922) when he used the name, *Leiboldia* could be regarded as properly published in 1847, since it was associated with a specific description and a binomial specific name. Under the "International Rules," as amended at the Amsterdam meeting (1935) (known to me only from T. A. Sprague's brief summary in Kew Bull. 1936: 185), the status of *Leiboldia* as first used in 1847 depends upon whether it is considered to have been used then as a "provisional name" (these are not regarded as validly published) or an "alternative name" (these are regarded as validly published). The question is complicated by the fact that the generic name in question (*Leiboldia*) does not stand by itself at all. The name *Leiboldia ovata* is certainly, in the most literal meaning of the word, an "alternative name" ("s." = seu or sive, *or*), and so, obviously is *Leiboldia arctioides.* In so far, by the letter of the law, these names are validly published. But is a genus *Leiboldia* published at the same place? And, if not, can specific names be validly published under a genus which has no technical existence?

It seems fairly clear that the generic name *Leiboldia,* under the International Rules, was not effectively published by Schlechtendal in 1847. The "genus or section" was based on two species, hence does not come under Art. 43 of the "International Rules" (1930) permitting the validation of the names of monotypic new genera by a combined generic-specific description. (The fact that I have been unable to distinguish the two supposed species, and so combine them under the name *V. arctioides*, does not alter the situation nomenclatorially.) Articles 40 and 41, so far as they go, do not indicate that it was validated; and Art. 42 appears to rule it out definitely. "The name of a genus is not validly published unless it is accompanied (1) by a description of the genus, or (2) by the citation of a previously and effectively published description of the genus under another name, or (3) by a reference to a previously and effectively published description of the genus as a subgenus, section or other subdivision of a genus." (Art. 42, Int. Rules, Cambridge, 1930.) Provisions (2) and (3) do not apply in this case. As to (1), there is certainly no generic description as such. Schlechtendal gives a fairly full description of the achene and pappus of *V. leiboldiana* in his account of that species, then states that the achene of *V. arctioides* differs in some respects, and goes on to say (translated) "This structure of the fruit strongly departs from that to be found in other Vernonias, where for example the achene is marked with longitudinal pilose sulci and alternate glabrous ones, or where series of pappus of diverse character crown the

achene. Hence I have proposed the name of a new genus or section, etc." (as above cited). This is certainly not a generic description in any proper sense. Although the names *Leiboldia ovata* and *L. arctioides* are published as "alternative names," the generic name *Leiboldia* itself is not. It is merely a suggested name for a "new genus or section," in which its own author did not have enough confidence to use it except in a subordinate way, and must consequently be regarded as a "provisional name" and thus not validly published. This being the case, the two "alternative" specific names made under it can have no better standing.

Bentham and Hooker[10] recognized *Leiboldia* as a section of *Vernonia* and gave a brief description. Curiously enough, they cited the name as of "Schlecht. ex Walp. Ann. **i.**: 388. Sch. Bip. in Liebm. Comp. exs. n. 478." In Walpers' Annales, at the page cited, Schlechtendal's description of *Vernonia leiboldiana* is copied under that name with the synonym added "*Leiboldia ovata* Schlechtd. mss." Schultz Bipontinus' manuscript use of the name, in Leibmann's exsiccatae, is of course not publication in any sense.

The first valid publication of *Leiboldia* as a genus was by Gleason[11] in 1906. The genus was described, with the type designated as *Vernonia leiboldiana* Sch. Bip., and 4 species were keyed and described. Unfortunately the genus and the two specific names previously made under it were all ascribed to Schultz Bipontinus, an error corrected in Gleason's 1922 treatment in the North American Flora. This being a self-evident error, it seems justifiable to cite the genus as of Schlechtendal ex Gleason, in view of the references given by Gleason.

PALEOBOTANY.—*A fossil shelf-fungus from North Dakota.*[1]

ROLAND W. BROWN, U. S. Geological Survey.

The Hell Creek formation, of Upper Cretaceous age, exposed at a number of localities along the Cannonball River in southwestern North Dakota, yielded only a few species of fossil plants to the writer during the field season of 1931. These remains consist chiefly of poorly preserved dicotyledonous leaves, and the twigs and cones of *Sequoia dakotensis* Brown.[2] The fragment to be described here as a fossil shelf-fungus was found 1 mile southwest of the old post office called Wade, in sec. 36, T. 131 N., R. 86 W. The identity of this specimen was, until recently, unsuspected; but the publication of a somewhat similar species, *Polyporites browni* Wieland[3] from the Lower

[10] Gen. Pl. **2**: 228. 1873.

[11] Bull. N. Y. Bot. Gard. **4**: 161. 1906.

[1] Published by permission of the Director, U. S. Geological Survey. Received May 4, 1936.

[2] BROWN, ROLAND W. *Some fossil conifers from Maryland and North Dakota.* This JOURNAL **25**: 447. 1935.

[3] WIELAND, G. R. *A silicified shelf fungus from the Lower Cretaceous of Montana.* Am. Mus. Nov. **725**: 1–13. 1934.

Cretaceous of Montana, in 1934, furnished the necessary suggestion leading toward what is thought to be a satisfactory identification.

Polyporites stevensoni, n. sp. Figs. 1, 2

Description.—This is a completely silicified specimen shaped like a piece of a broken plano-convex lens, 3 cm in diameter, 1 cm thick, flat on the upper surface, and curved on the under surface to the rounded edge. Both upper and lower surfaces show crowded, circular to angular pits, averaging 2 mm in diameter; and a radial longitudinal section shown in Fig. 1 reveals irregular portions of the hymenial tubes or pores. Thin sections, both transverse and longitudinal, show no further structure or spores under magnification. In brief, this fossil represents the spore-bearing or hymenial portion of a polyporaceous fungus. As in Wieland's specimen of *Polyporites browni,* this also lacks the upper portion of the sporophore or context; but this absence must not be regarded as evidence against the identification of the specimen as a shelf-fungus, because, in many living species of Polyporaceae, the context may, for one reason or another, become dissociated from the pore layer.

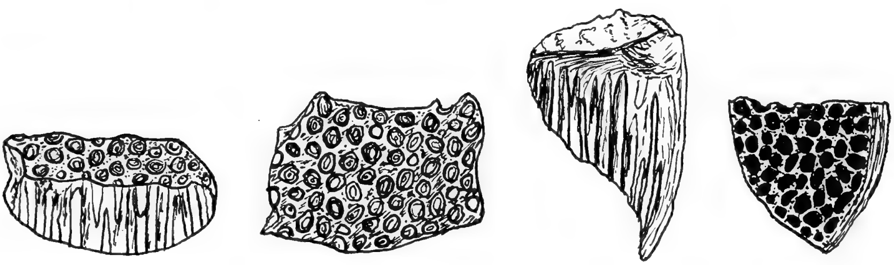
1 2 3 4

Fig. 1.—Upper surface and radial section of *Polyporites stevensoni,* n. sp. Fig. 2.—Under surface of *P. stevensoni.* Fig. 3.—Upper surface and radial section of *Hexagonia gunnii* Berkeley, U. S. Nat. Mus. Cat. No. 15962. Fig. 4.—Under surface of *H. gunnii.* All figures natural size.

Remarks.—A living polyporaceous genus with which *Polyporites stevensoni* may be allied is *Hexagonia,* with about 50 species distributed in the warmer latitudes of the world. Figs. 3 and 4 show the side and under views of *H. gunnii* Berkeley taken from *Eucalyptus gomphocephala* near Fremantle, Australia. It will be noted that the pores in species of this genus are of a size and shape more nearly comparable to those of the fossil than are the much smaller pores in most species of the genus *Polyporus.* Although its affinities, therefore, seem to be with *Hexagonia,* it nevertheless seems best, because of the lack of further distinguishing characters, to assign the fossil to *Polyporites,* in the sense that the latter is a genus illustrating the general characters of the family Polyporaceae rather than the particular characters of the genus *Polyporus.*

The habit of *Polyporites stevensoni* is conjectural; and the fact that it was found associated with the fossil cones of *Sequoia dakotensis* does not necessarily mean that it lived on *Sequoia.* It may have lived on any one of a number of other coniferous or dicotyledonous trees that are known to have

inhabited the same or adjoining regions in the same portion of Upper Cretaceous time. If the surmise that *P. stevensoni* is related to *Hexagonia* be well founded, then the presence of this fungus in the Upper Cretaceous flora of North Dakota is harmonious with what is known of the rest of the flora which, because of the presence of some ferns, palms, figs, magnolias, etc., is regarded as having been of a warm temperate or subtropical type. The descendants, or at least the most nearly comparable living species to many of these Upper Cretaceous fossils, are now restricted to southern latitudes; and it is a logical inference that the fungi should follow their hosts in the retreat before inhospitable climatic and ecologic conditions.

Polyporites stevensoni can be distinguished from *P. browni* Wieland by its much larger pores. The only other recorded fossil species from the western hemisphere is *P. sequoiae* Heer,[4] from the Eocene of Greenland, and so named because Heer thought it possible that the specimen may have grown upon a *Sequoia*, several species of which were found at the same locality. Unfortunately Heer's specimen shows only the upper or context portion of the fungus, so that no comparison can be made with either *P. browni* or *P. stevensoni*.

The name *stevensoni* is given for John A. Stevenson, of the Bureau of Plant Industry and Custodian of the C. G. Lloyd mycological collections of the Smithsonian Institution, for his generous help in identifying the present specimen.

Occurrence.—Hell Creek formation, Upper Cretaceous, sec. 36, T. 131 N., R. 86 W., near Wade, North Dakota.

Type.—In U. S. National Museum.

ZOOLOGY.—*Two new flying squirrels from Mexico.*[1] E. A. GOLDMAN, Biological Survey.

Flying squirrels occur in widely separated areas in the higher mountains of Mexico, but appear to be rare as very few specimens have been obtained by collectors. In the course of the extensive field work by E. W. Nelson and myself the species was actually encountered only once when the two individuals on which *Glaucomys volans goldmani* was based were captured in the mountains of Chiapas.

In March, 1926, three specimens of *Glaucomys volans* were presented to me by the distinguished Mexican naturalist, Prof. Alfonso L. Herrera, then Director of Biological Investigations and in charge of the National Museum of Natural History of Mexico. Prof. Herrera informed me that two of these were from the Sierra Madre of Chihuahua, and the name of the state had been written on one of the labels. The third specimen, according to Herrera, was taken in the moun-

[4] HEER, OSWALD. *Flora fossilis arctica* **3** (3): 7, pl. 1, fig. 1a, 1874.

[1] Received September 28, 1936.

tains of Vera Cruz, but exact locality data could not be furnished by him in either case. No other specimens from Mexico are known to me and as these appear to represent two new forms it seems desirable to direct attention to them with a view to stimulating the collection of others. It may be that the rarity of the species in Mexico is more apparent than real.

One of these subspecies is named for Prof. Herrera in recognition of his work in diverse biological fields during many years.

Glaucomys volans herreranus, subsp. nov.

Vera Cruz Flying Squirrel

Type.—From mountains of Vera Cruz, Mexico. No. 261695, ♀ young adult, skin and skull, U. S. National Museum (Biological Survey collection), prepared by Luis G. Rubio, November 8, 1924. X-catalogue number 27589.

Distribution.—Known only from the region of the type locality where cloud forest conditions tend to prevail.

General characters.—Color darkest of the *Glaucomys volans* group. Similar in size to *Glaucomys volans goldmani* of the mountains of Chiapas, but color decidedly darker—upper parts near cinnamon brown (Ridgway, 1912), instead of near sayal brown; under sides of membranes and tail light pinkish cinnamon, instead of pinkish buff. Contrast in color still greater when compared with *Glaucomys volans texensis* of eastern Texas.

Color.—*Type:*—Upper parts in general from middle of face and top of head to rump near cinnamon brown, becoming deep glossy black on upper surfaces of membranes; under surfaces and margins of membranes, and inner sides of thighs overlaid with light pinkish cinnamon; rest of under parts white tinged with pale pinkish buff; orbital margins and postorbital areas distinctly blackish; feet dark brownish; tail cinnamon brown above, light pinkish cinnamon below.

Skull.—Skull of type fragmentary, apparently similar to that of *goldmani.*

Measurements.—*Type* (approximated from dry skin):—Total length, 198 mm; tail vertebrae, 89; hind foot, 30. *Skull* (no very dependable measurements available).

Remarks.—*G. v. herreranus* is based on a single specimen from the rain forest region of Vera Cruz. It appears to represent a geographic race characterized by remarkably dark coloration associated, as in other species, with dimly lighted heavy forest interiors.

Glaucomys volans madrensis, subsp. nov.

Chihuahua Flying Squirrel

Type.—From Sierra Madre, Chihuahua, Mexico. No. 261694, adult (sex ?), skin and skull, U. S. National Museum (Biological Survey collection), received from A. L. Herrera, March, 1926. X-catalogue number 27588.

Distribution.—Sierra Madre of Chihuahua; reports suggest a range in the mountains as far south as Guerrero, southwestern Mexico.

General characters.—Similar in general to *G. v. texensis* of eastern Texas, and to *G. v. goldmani* of Chiapas, but paler than either, fore feet white instead of dusky, and cranial details slightly different. Contrasting strongly in paler coloration compared with *G. v. herreranus* of Vera Cruz.

Color.—*Type* (worn pelage):—Upper parts overlaid with buffy gray, becoming pale rusty on rump and brownish black on upper surface of membranes; under parts white, varying to light buff on under surfaces of membranes; eyes narrowly rimmed with black, the postorbital areas distinctly grayish; fore feet white; hind feet dusky over metatarsus to toes, the toes whitish; tail much worn, dull brownish above, pinkish buff below. A topotype in less worn pelage is very similar in color, but less rusty above and the tail is paler buff below.

Skull.—Closely resembling that of *texensis*, but rostrum slightly less depressed, the upper outline rising less steeply to vault of cranium; audital bullae slightly smaller, less inflated; dentition about the same. Very similar to that of *goldmani*, but nasals shorter; audital bullae smaller.

Measurements.—*Type* (approximated from dried skin):—Total length, 220 mm; tail vertebrae, 88; hind foot, 31. *Skull* (type): Greatest length, 34.5; condylobasal length, 31.3; zygomatic breadth, 21.4; interorbital constriction, 7.2; width across squamosals behind zygomata, 17.2; maxillary toothrow (alveoli), 6.4.

Remarks.—The two specimens available of this subspecies indicate pallid coloration as the best distinguishing feature. The white fore feet are particularly notable.

ENTOMOLOGY.—Poecilocryptus *and* Poecilopimpla (*Hymenoptera: Ichneumonidae*).[1] R. A. CUSHMAN, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

In 1901 Cameron (Ann. Mag. Nat. Hist., ser. 7, **7**: 527) and Kriechbaumer (Zeits. Hym. Dip., **1** (5): 252) each described a new genus under the name *Poecilocryptus.* Morley (Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 35) renamed Cameron's genus *Poecilopimpla* on the supposition that it was preoccupied by *Poecilocryptus* Kriechbaumer. As a matter of fact the preoccupation was undoubtedly the reverse of that assumed by Morley, for Cameron's genus was published in June and Kriechbaumer's probably months later, for it appeared in the undated fifth issue of a six-issue periodical, the first number of which appeared in January. Further evidence is furnished by the dates of the reviews in *Wiener Entomologische Zeitung* for 1901 of certain other articles appearing in Zeitschrift für systematische Hymenopterologie und Dipterologie of 1901. An article by Krieger in heft 3 of the latter was reviewed on page 136 of *Wiener Entomologische Zeitung* issued on August 15, 1901; an article by Stein in heft 4 was reviewed on page 190, issued on November 25; and one by Bezzi in heft 5, in which Kriechbaumer's article also appeared, was reviewed on page 233, issued December 25. This would seem to indicate that heft 5 appeared not long before, perhaps after, November 25.

[1] Received May 13, 1936.

In proposing *Poecilopimpla* for supposedly preoccupied *Poecilocryptus* Cam., Morley overlooked the fact that Cameron had already (Jour. Straits Br. Roy. Asiatic Soc., **39:** 140, 1903) used that name.

The necessity for the renaming of *Poecilocryptus* Kriechbaumer is obviated by the fact that the same genus appears certainly to have been redescribed by Viereck under the name *Photocryptus*.

Poecilocryptus Cameron

Poecilocryptus Cameron, Ann. Mag. Nat. Hist., ser. 7, **7:** 527. 1901 (not Kriechbaumer, 1901).

Poecilopimpla Morley, Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 35 (not Cameron, 1903).

Poecilocryptus Turner and Waterston, Proc. Zool. Soc. London, 1920, p. 24, figs. 8a, 11b.

It is fortunate that circumstances permit the restoration of Cameron's genus and the elimination of Morley's, for the latter gives an erroneous impression of the relationship of the genus. It is certainly cryptine, not pimpline as Morley would have us believe.

Poecilocryptus nigromaculatus Cameron

Poecilocryptus nigromaculatus Cameron, Ann. Mag. Nat. Hist., ser. 7, **7:** 528, 1901.

Poecilopimpla nigromaculata Morley, Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 36.

Poecilocryptus nigromaculatus Turner and Waterston, Proc. Zool. Soc. London, 1920, p. 26, figs. 8a, 11b.

Before me are two specimens of each sex reared from flower galls on *Acacia dealbata* at Bathurst, N. S. W., in December 1933, by Y. S. Noble. They differ from Cameron's description only in their smaller size and in lacking the black spot on the outer side of the hind femur.

Poecilocryptus inflexa (Morley) n. comb.

Poecilopimpla inflexa Morley, Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 37.

This may, as stated by Morley, represent a distinct genus, but it is unknown to me and must for the present stand in *Poecilocryptus*.

Photocryptus Viereck

Poecilocryptus Kriechbaumer, Zeits. Hym. Dip., **1:** 252. 1901. (not Cameron, 1901), new synonymy.

Photocryptus Viereck, Proc. U. S. Nat. Mus., **46:** 379. 1913, Cushman, Proc. U. S. Nat. Mus., vol. 79, art. 14, 1931, p. 2.

I have not seen the genotype of *Poecilocryptus* Kriechbaumer, but the agreement, both in structure and in color pattern, of *Photocryptus pachymenae* (Cresson) with the original description is so close that I have no hesitation in synonymizing the two genera.

Photocryptus nigrosignatus (Kriechbaumer), n. comb.

Poecilocryptus nigrosignatus Kriechbaumer, Zeits. Hym. Dip., **1**: 252. 1901.

POECILOPIMPLA Cameron

Poecilopimpla Cameron, Jour. Straite Br. Roy. Asiatic Soc., **33**: 140. 1903 (not Morley, 1914).

This genus is unknown to me, but the descriptions of the genus and of its type species, especially of the propodeum, suggest *Theronia* Holmgren.

PHYSIOLOGY.—*A comparative study of the olfactory and trigeminal reflexes elicited by various vapors in different mammals.*[1]

WILLIAM F. ALLEN, University of Oregon Medical School, Portland, Oregon.

Ignorance of the action of certain odoriferous vapors on the olfactory, trigeminal and vagal endings in the same and different species of mammals has resulted in no end of confusion in studying ordinary and conditioned reflexes. It has been known for some time that inhalation or insufflation of phenol, camphor, eucalyptus, pyridin, alcohol, ether, chloroform etc. into the nostrils produce certain changes in respiration, pulse and blood pressure over either the olfactory or trigeminal nerve and hence are of no value as olfactory stimulants unless the trigeminal branches to the upper respiratory mucosa are eliminated. Several of the powerful irritating vapors for the trigeminal and vagi are also effective over the olfactory nerves. In response to this need for a comparative study of these reflexes in different species of mammals this study has been undertaken.

The earlier work on these reflexes in mammals by Kratschmer, Gourewitsch, Henry and Verdin, Sandman, Bayer, Zagari, Brodie and Russel, Seemann, Roger, Mayer et al., Craigie, Larsell and Burget and similar studies in man by Russi, Ponzo, Malan, Crosland et al. has been reviewed in earlier publications (1 to 4). Cromer and Ivy and Gesell et al. have recently pointed out the necessity of considering the stellate ganglion in studying the lower respiratory reflexes. The recent studies of Ciurlo and Kerkes have contributed but little to our knowledge of olfactory and trigeminal reflexes.

Procedure.—Thoracic respiration was recorded on a kymograph by a tambour connected to a balloon strapped to the thorax or in small animals by a lever hooked to the skin of the thorax. Insufflations were from a blowing bottle that had single or double connections to the nostrils. Inhalations were from wide mouthed bottles which con-

[1] Received June 26, 1936.

tained cotton and a few drops of the inhalant. These bottles were held 10 mm distant and further from the nostrils depending on the volatility of the vapor. The odors and mild irritants were usually inhaled, for previous experiments and many of the negative records in this study demonstrate that respiration was unaffected in animals deprived of olfactory and trigeminal sensations even after more prolonged inhalations through the nostrils or a tracheal cannula. Strong irritants were generally insufflated and stimulations were limited to the olfactory or trigeminal nerves by severing one or the other and inserting a tracheal cannula towards the lungs and a laryngeal cannula into the pharynx.[2] The tests were made under light hypnosis of some barbiturate, light ether or no anesthetic. One must be very careful about the stage of anesthesia in dogs for it was shown in (5) that the olfactory-respiratory reflex is abolished during the first stage of anesthesia, at about the stage of unsteady walking. The eyes were blinded or blindfolded and ears stopped with cotten except when anesthesia was deep.

For convenience the following terms were introduced in papers (1) and (3). An *olfactory* animal is one in which stimulations from vapors was limited to impulses traversing the olfactory nerves, produced by severance of the nasal branches of the trigeminals and elimination of other nerves. A *trigeminal* animal has its vapor stimulations limited to the trigeminal nerves through severance of the olfactory bulbs from the hemispheres and elimination of other nerves.

OLFACTORY-RESPIRATORY REFLEXES

Rabbits.—Numerous tests made on three rabbits during light hypnosis or without any anesthetic are in complete accord with the results reported in (3). Typical tests show that anise, lavender (paper 3, Fig. 1, D) and cloves cause some depression and slowing of respiration. The response to anise and cloves is usually more pronounced than for lavender. Many of the mild irritants as phenol (sheep dip), camphor, eucalyptus, wintergreen (paper 3, Fig. 1), alcohol, ether and chloroform were very affective in depressing and slowing respiration. Even the strong irritants formalin, mustard, acetic acid and ammonia (paper 3, Fig. 1) depress and slow respiration. As previously noted by Bayer and the writer the coal tar products xylol (paper 3, Fig. 1) and benzol produce powerful effects on respiration, usually arresting it for a time and often eliciting cries. On the other hand some of the so-called

[2] Attention is called to a negative ammonia record under these conditions when both trigeminal and olfactory nerves were severed and to the air control graphs (papers 1 and 3).

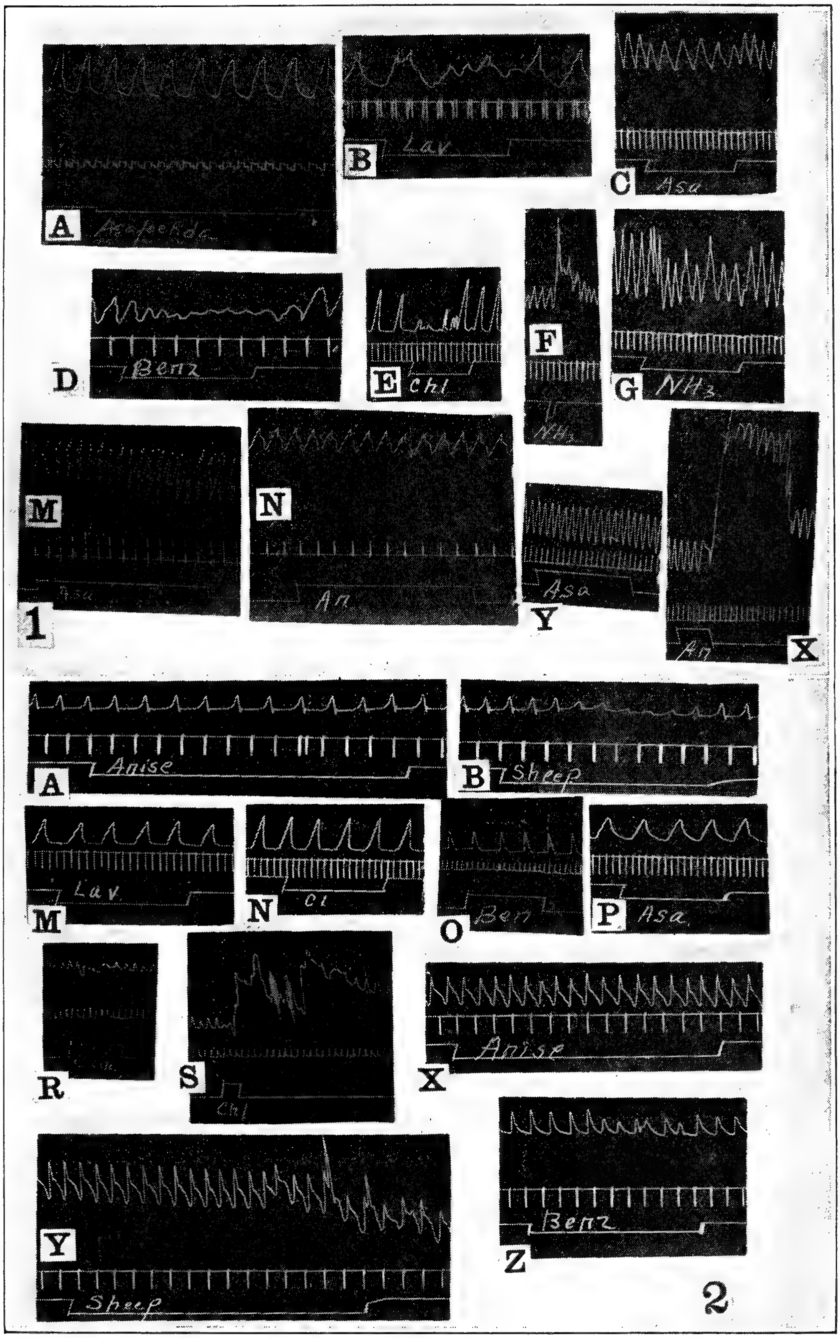

Fig. 1.—Thoracic respiratory tracings taken at time of inhaling or insufflating a vapor into the nostrils. Top row is a respiratory tracing; middle row time in seconds; bottom row interval of stimulation. A, asafetida record from *olfactory* rabbit. B to G *olfactory* dog records; B, lavender; C, asafetida; D, benzol; E, chloroform; F, insufflation ammonia; G, inhalation ammonia. M and N nerve intact rat records; M, asafetida; N, anise. X and Y nerve intact guinea pig records; X, anise; Y, asafetida.

Fig. 2.—Similar arrangement of tracings to Fig. 1: A and B *trigeminal* rabbit records; A, anise; B, sheep dip. M to S *trigeminal* dog records; M, lavender; N, cloves; O, benzol; P, asafetida; R, camphor; S, chloroform. X to Z *trigeminal* rat records; X, anise; Y, sheep dip; Z, benzol.

disagreeable odors, as previously noted by Bayer and the writer, have little or no effect on respiration. Asafetida (Fig. 1, A) has never evoked any response nor has fresh cat's urine, or skunk extract, but pyridin generally depresses respiration in an *olfactory* rabbit. Occasionally a vapor will cause sniffing which simulates acceleration in a record.

Dogs.—The following inhalation and insufflation tests are illustrative of many taken from 6 dogs in which stimulation was limited to olfactory conduction. Inhalation of the so-called agreeable odors lavender (Fig. 1, B) anise, cloves and wintergreen and the disagreeable odors asafetida (Fig. 1, C) butyric acid and pyridin depressed and slowed respiration. Of these lavender proved the most effective stimulant. As noted for rabbits the occasional sniffing simulates acceleration. Benzol (Fig. 1, D) and xylol generally brought respiration to a standstill for a time, but the psychic effects, as indicated by cries, were nil when compared to rabbits. Camphor, eucalyptus, phenol, alcohol, ether and chloroform (Fig. 1, E) evoked considerable depression and slowing of respiration, but no more than lavender in the same concentrations. Insufflation of formalin, acetic acid and ammonia (Fig. 1, F) frequently arrested respiration and produced body movements. The effect of inhaling ammonia for several seconds at a distance of several inches from the nostrils (Fig. 1, G) was less pronounced than insufflation for a second (Fig. 1, F).

Nerve intact rats.—Numerous tests from 5 rats which had received sufficient nembutal intraperitoneally to put them into a state of anesthesia in which they walked with a slightly unsteady gait showed not only an absence of respiratory responses from asafetida (Fig. 1, M) but also from anise (Fig. 1, N), cloves and lavender. The acceleration which occasionally followed any of these inhalants was presumably psychic effects. Sheep dip phenol, butyric acid, camphor, chloroform, xylol and benzol caused slight to considerable depression and slowing of respiration.

Nerve intact guinea pigs.—The following tests are illustrative of many made on 3 animals under very light nembutal hypnosis (0.3 cm^3 per 800 grams weight). Inhalation of anise (Fig. 1, X) produced marked depression and slowing of respiration and frequently body movements, while lavender and cloves generally evoked only slight inhibition of respiration. Asafetida (Fig. 1, Y) should I think be reported as giving negative results. However, a few records show some irregularities during the time of stimulation, which are at best very doubtful inhalation reflexes. Chloroform and benzol depressed and

slowed respiration considerably, but the effects from benzol were less pronounced than in *olfactory* rabbits.

TRIGEMINAL RESPIRATORY REFLEXES

Rabbits.—Numerous tests from 3 *trigeminal* rabbits have for the most part confirmed everything reported in (3). Inhalation of anise (Fig. 2, A), cloves, lavender (paper 3, Fig. 1, F) and asafetida in no way affected respiration. Pyridin not only depressed and slowed respiration but frequently caused body movements. Wintergreen (paper 3, Fig. 1), sheep dip (Fig. 2, B), camphor[3] and eucalyptus caused some depression and slowing of respiration, while xylol (paper 3, Fig. 2), benzol, alcohol, ether and chloroform frequently arrested respiration for a time and caused body movements. Insufflation of the strong irritants, formalin, acetic acid and ammonia into the nostrils caused complete arrest of respiration, body movements and often a sneeze. Inhalation of these vapors 4 to 6 inches from the nose did not bring about complete suppression of respiration.

Dogs.—Many inhalation tests of lavender, cloves, anise, wintergreen, asafetida, benzol and xylol (Fig. 2, M, N, O and P) resulted in absolutely no change in respiration in 6 *trigeminal* dogs. Since all of these vapors inhibited respiration in *olfactory* dogs they will have to be regarded as solely olfactory stimulants in dogs. Inhalation of pyridin, butyric acid, camphor[3] (Fig. 2, R), eucalyptus, phenol and sheep dip generally caused depression and slowing of respiration and not infrequently movements of the head. One dog in which respiration was unaltered by sheep dip responded readily to phenol. Inhalation of ether, alcohol and chloroform (Fig. 2, S) elicited considerable depression and slowing of respiration and movements of the head. Chloroform seemed to be the most effective of the three. Insufflation of the strong irritants formalin, acetic acid and ammonia resulted in arresting respiration, body movements and frequently a sneeze. The relative strengths of these stimulants seemed to be in the order mentioned and the response from formalin is somewhat delayed. Inhalation of ammonia some distance from the nostrils for several seconds was less effective than insufflation for a second.

Rats.—As was to be expected from the tests on nerve intact rats the inhalation records of anise (Fig. 2, X) cloves, lavender and asafet-

[3] The efficiency of camphor for a trigeminal stimulant depends largely on the concentration of the vapor. It is advantageous to shake the crystals violently in the bottle before inhalation and bottle should remain corked until time for inhalation. Failure to observe these conditions may have been the cause for some of the negative results obtained in my earlier work.

ida from 4 *trigeminal* rats showed no change in respiration. Camphor, eucalyptus and butyric acid produced slight or no effect. Sheep dip (Fig. 2, Y), pyridin, wintergreen, xylol, benzol (Fig. 2, Z) and chloroform usually depressed and slowed respiration; the response from sheep dip and benzol is slower in appearing and less effective than in rabbits, but may produce body movements in either case. The records from pyridin and chloroform generally show body movements. No insufflation tests were made from the strong irritants, but short inhalations of ammonia produced considerable inhibition of respiration.

DISCUSSION

It is clear from these and previous tests that the olfactory or trigeminal inhibition obtained from inhalation or insufflation of the same vapor in two different species of mammals not only may show considerable variation in intensity or speed of action, but the same vapor may be very effective in one species and non-effective in another.

TABLE 1.—A SUMMARY OF BEHAVIOR OF VAPORS ON RESPIRATION

	Over olfactory n.		All nerves intact			Over trigeminal nerve			
	Rabbits	Dogs	Man	Rats	G. Pigs	Rabbits	Rats	Dogs	Man
Lavender	+	+	+	0	+	0	0	0	0
Anise	+	+	+	0	+	0	0	0	0
Cloves	+	+	+	0	+	0	0	0	0
Asafetida	0	+	+	0	0	0	0	0	0
Butyric acid	0+	+	+	0+		0+	0+	+	0
Wintergreen	+	+	+	+		+		0	0
Xylol	+	+	+	+		+	+	0	0
Benzol	+	+	+	+	+	+	+	0	+0
Pyridin	+	+	+	+		+	+	+	+
Camphor	+	+	+	+		+	+0	+	+
Eucalyptus	+	+	+	+		+	+0	+	+
Alcohol	+	+	+			+		+	
Ether	+	+	+			+		+	+
Chloroform	+	+	+	+	+	+	+	+	+
Sheep dip	+	+		+		+	+	+−	
Phenol	+	+	+	+		+	+	+	
Formalin	+	+	+			+		+	+
Acetic acid	+	+	+			+		+	+
Ammonia	+	+	+			+	+	+	+

Table 1 is included to permit of instant comparison of the behavior of a number of vapors on respiration in several animals (man supplied from paper 4) over the olfactory and trigeminal nerves and nerve intact animal.

It is obvious from the table that the purely olfactory vapors affecting respiration in rabbits include anise, cloves and lavender. In dogs

and one human anosmic wintergreen, asafetida, xylol and benzol (? in anosmic) will have to be added to the list for the rabbit. Asafetida is negative for nerve intact rabbits, rats and guinea pigs. Inasmuch as respiration is unchanged in *trigeminal* or nerve intact rats from inhalation of anise, cloves, lavender and asafetida, but is inhibited from xylol and benzol in *trigeminal* rats; it is questionable if any vapor alters respiration solely over the olfactory nerve in rats. There are apparently few, if any, vapors which affect respiration solely over the trigeminal nerve in any mammal. The coal tar products xylol and benzol are powerful olfactory-respiratory inhibitors in all mammals.

In a previous paper (3) anise was reported as inhibiting respiration over the trigeminal nerve in rabbits. This unexpected result is to be explained by the fact that the anise used in the earlier work was obtained from an unknown source. The anise used in these tests is a Fritzsche Bros. product and U.S.P. The response of this anise is only over the olfactory nerves.

The olfactory and trigeminal respiratory reflexes from vapors are inhibitory. Together with the vagus mechanism they constitute a protective mechanism for keeping dangerous and non-dangerous vapors out of the lungs. The acceleration (usually sniffing) and lengthening of the respiratory excursions which occasionally occur from odors appear to be of psychic origin. The chemical stimulation for maintenance of proper oxygen content for the blood seems to be executed chiefly from carotid sinus and aortic nerves and does not take place until the blood changes color and there is an actual need for increased respiration.

It is suggested from work in progress on conditioned smell reflexes in dogs that the relative efficiency of various vapors for eliciting conditioned reflexes from olfactory or trigeminal origin is in direct relationship to their ability to alter respiration. In addition previously reported respiratory tracing from an anosmic and normal students during inhalation of various vapors were for the most part in accord with the sensations perceived. Whenever a difference was observed, respiration was more sensitive. Hence the writer believes that the olfactory or trigeminal respiratory reflex serves as a correct index of the sensitivity of that vapor.

SUMMARY AND CONCLUSIONS

The effect of various inhaled and insufflated vapors on respiration in several species of *olfactory*, *trigeminal* and nerve intact mammals is tabulated in the discussion.

It is clear from this table that dogs and man agree in that lavender, anise, cloves, wintergreen, asafetida, xylol and benzol (? in man) alter respiration only through olfactory stimulation; while in rabbits the purely olfactory vapors affecting respiration are confined to anise, cloves and lavender, asafetida being negative in the intact animals and the other responding over the trigeminals as well as the olfactory nerves. Anise, lavender, cloves, and asafetida are non-responsive under all conditions in rats.

These tests suggest wide variation of the olfactory sensitivity in different species of mammals. Attention is directed to the apparent similarity in man and the dog and the dissimilarity in rats.

All of the irritating vapors tested altered respiration over the olfactory as well as the trigeminal nerves.

The possibility of utilizing the respiratory reflex as an index for sensitivity of perception of an odoriferous or an irritating vapor is considered in the discussion.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

RECENTLY ELECTED TO MEMBERSHIP IN THE ACADEMY

Eugene Curtis Auchter, principal horticulturist in charge, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry and Assistant Chief of Bureau, was elected to membership in recognition of his work in horticultural science, especially his researches on apple and peach culture, the pruning and fertilization of orchards, fruit pollination and fruit spur growth, the biennial bearing of apple trees, and the effect of light upon plants.

Thomas Fredrik Wyebye Barth, professor, Mineralogical Institute, University of Oslo, was elected to membership in recognition of his studies in mineral petrography and the application of X-ray methods in the elucidation of petrographic problems.

G. Arthur Cooper, assistant curator, stratigraphic paleontology, U. S. National Museum, was elected to membership in recognition of his studies in Devonian stratigraphy and in the class Brachiopoda.

William Adams Dayton, senior plant ecologist, U. S. Forest Service, was elected to membership in recognition of his contributions to botany and forestry, especially his researches in range management.

George Flippo Gravatt, senior pathologist, Bureau of Plant Industry, was elected to membership in recognition of his research on forest disease control, particularly introduced epidemic diseases.

Ernest Everett Just, professor of Zoology and head of department, Howard University, was elected to membership in recognition of his contributions to experimental embryology and cytology, fertilization, artificial parthenogenesis, and physiology of development.

Gordon M. Kline, chief, organic plastics section, National Bureau of Standards, was elected to membership in recognition of his research work in organic chemistry and in particular his work on the polymerization of olefins.

Walter C. Lowdermilk, associate chief, Soil Conservation Service, was elected to membership in recognition of his contributions to forestry and soil erosion control.

Klare S. Markley, associate biochemist, Bureau of Chemistry and Soils, was elected to membership in recognition of his achievements in organic and biological chemistry.

Emilio P. Meinecke, principal pathologist, Bureau of Plant Industry, U. S. Department of Agriculture, San Francisco, California, was elected to membership in recognition of his notable contributions to forestry, especially research in forest pathology.

William R. Osgood, materials testing engineer, National Bureau of Standards, was elected to membership in recognition of his contributions to the application of the theory of elastic and plastic deformations of materials to the designs of engineering structures.

FRANK M. SETZLER, executive curator, Department of Anthropology, U. S. National Museum, was elected to membership in recognition of his researches in prehistoric cultures of the Mississippi Valley and Texas.

JULIAN H. STEWARD, associate ethnologist, Bureau of American Ethnology, was elected to membership in recognition of his contributions to anthropology, in particular, researches among the Shoshonean tribes, southwest archeology, and Columbia River archeology.

GEORGE P. WALTON, assistant chemist, Bureau of Plant Industry, was elected to membership in recognition of his contributions to agricultural soil and fertilizer chemistry.

PHILOSOPHICAL SOCIETY

1087TH MEETING

The 1087th meeting was held in the Cosmos Club Auditorium, Saturday, October 12, 1935, President GISH presiding.

The program consisted of an invited paper by J. BARTELS of Eberswalde, Germany on *Some aspects of geophysical cycles.*

An extended abstract of this paper which was discussed by Messrs. DICKINSON, HAWKESWORTH, KRACEK, SILSBEE and others will be found in this JOURNAL **26**: 195–199. 1936.

1088TH MEETING

The 1088th meeting was held in the Cosmos Club Auditorium, Saturday, October 26, 1935, President GISH presiding.

Program: L. R. MAXWELL: *Recent applications of electron diffraction to molecular structure.*—The method of electron diffraction was discussed in relation to the determination of the valence angle of the oxygen atom in several different types of molecules. The valence angle of oxygen for the water molecule is known from spectroscopic data to be very close to 105°. Electron diffraction studies by various workers have been made for F_2O, Cl_2O, $(CH_3)_2O$, $(C_6H_4I)_2O$. The valence angle becomes greater for the more complex molecules, 4,4′ diiododiphenyl ether $(C_6H_4I)_2O$ having a value of 118°.

Phosphorous and arsenic vapors were studied by electron diffraction and the structures of the P_4 and As_4 molecules determined. Both molecules were shown to be in the form of regular tetrahedrons with the P-P distance 2.21Å and the As-As separation 2.44Å. These results were discussed in connection with the existing X-ray data on the structure of various forms of phosphorous and arsenic. The minimum atomic distances as found by the crystal structure analysis for phosphorous and arsenic are approximately the same as for the atomic separations obtained by electron diffraction from the gas molecules. This shows that these distances do not change greatly when the bond angle decreases from 100 to 60°. (*Author's Abstract.*)

A. K. BREWER: *Mass spectrographic determination of the atomic weight and the abundance ratios of the isotopes of potassium in mineral and organic matter.*—The constancy of the atomic weight of potassium in nature has been the subject of many investigations, but due to the difficulties involved in the chemical determination of the atomic weight as well as the insensitivity of the method, no definite results have been obtained. A mass-spectrographic method for making comparative atomic weight determinations has now been

developed which permits of an accuracy at least ten times that obtainable by the most exact chemical means.

The investigation so far has been extended to ocean water, mineral and organic tissues. The results obtained for Pacific Ocean water, taken at various points over the surface and down to depths of 2500 meters, show that the atomic weight is close to 39.094, and that it is constant irrespective of locality and depth to within 0.00025. Potassium in minerals taken at various points over the earth's crust is very nearly as constant as ocean water, although slight deviations are observed. Organic tissues, in contrast, exhibit marked deviations. In the case of plants the atomic weight is a function of (1) the nature of the plant, (2) the age of the plant, (3) the section of the plant and (4) the soil in which the plant is grown. Results for animal tissues are incomplete, but they do show appreciable variations from organ to organ and some effect due to the age of the animal; bone marrow, for instance, is high in the heavy potassium isotope while hair, tallow and red meat are low. The significance of the fact that living tissues tend to preferentially concentrate one or the other of the potassium isotopes is not clear from the results so far obtained, although it must be looked upon as an indication that the isotopes may have somewhat different functions in the living processes. (*Author's Abstract.*)

These papers were discussed by Messrs. HAWKSWORTH, KRACEK, BRICKWEDDE, CURTIS, GISH, and SEEGER.

1089TH MEETING

The 1089th meeting was held in the Cosmos Club Auditorium, Saturday, November 9, 1935, President GISH presiding.

Program: G. R. WAIT and A. G. MCNISH: *Atmospheric ionization near the ground during thunderstorms.*—The rate of ionization inside a thin-walled vessel has been recorded on the grounds of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, during the past year. The rate of ionization was found to undergo an abnormal increase at the time of a thunderstorm. This increase has an abrupt beginning, coinciding with the beginning of the rain. The ionization decreases as soon as the rain ceases to fall. The curve which represents this decrease in ionization is substantially similar to the decay-curve for radium B. The increase in the rate of ionization, therefore, is attributed to radium B, and radium C in equilibrium with it, which must have been brought down by the rain, having become attached to the raindrops before they fell. It follows that large quantities of radioactive material must be present inside a thunder-cloud. The presence of such material can be fully accounted for on the assumption that vertical air-currents, which always occur during the formation of thunderstorms, carry it from the earth's surface into the clouds. The presence of radioactive material in a thunder-cloud is of considerable significance in atmospheric electricity, especially in connection with theories as to origin of penetrating-radiation associated with thunderstorms, recently detected by Schonland, and in connection with the theory of the maintenance of the earth's electric charge as put forward by C. T. R. Wilson. (For complete paper see Mon. Weath. Rev. **62**: 1–4. 1934.) (*Author's Abstract.*)

ROSS GUNN: *Electricity of rain and thunderstorms.*—ELECTRICITY OF RAIN.—It is shown that the observed properties of rain-drops of very different histories are readily described if each water-droplet and the surrounding ionized water-vapor is considered an electrical concentration-cell. The potential difference between the drop and points several radii outside approximate

0.06 volt. The equilibrium-charge on each droplet is proportional to the radius and is positive if the droplet is evaporating and negative if it is condensing. These droplets grow by association into large rain-drops and thus build up large charges of the order of 1/50 e.s.u. which discharge by conduction in a time of the order of 10^3 seconds. The drops thereafter take on an equilibrium-charge depending upon the evaporation or condensation of the drop and its size. The calculated charges are in agreement with observation. A laboratory experiment verifying certain aspects of the predicted effect is described.

A THEORY OF THUNDERSTORM-ELECTRICITY.—It is shown that in the presence of a rapidly rising current of air and the formation of rain-drops greater than a critical size, separation of charge takes place. At levels of condensation the atmospheric ions (usually positive) are swept to great heights while the newly-formed rain (usually negative initially) falls. Both charge-distributions discharge by conduction at different rates, leaving the charge in the zone of rain-formation in excess (usually negative). The excess charge induces charges on the Earth or on the high conducting atmosphere of a magnitude equal to a large fraction of the excess charge. Rain-drops formed by the association of droplets below the saturation-level impart a normally positive space-charge to the region. The charge-distribution resulting from the separation is quantitatively calculated from physical data and agreement obtained with observation in regard to the potential differences, electrical field, electric moment, charging current, recovery-time, and the average charge on the precipitated rain.

MAINTENANCE OF THE EARTH'S CHARGE.—Some objections to Wilson's thunderstorm-theory of the maintenance are noted. It is shown that special thunderstorm-conditions in mountainous regions are such that a total storm-area of 0.01 per cent of the Earth's surface would precipitate sufficient negative charge on rain and transfer enough positive charge upward by convection to maintain the field. The possible importance of forced vertical convection over natural barriers in *fair-weather* regions is considered and it is shown that such a systematic convection may account for an appreciable part of the necessary replenishing current.

DISTRIBUTION OF FREE SPACE-CHARGE.—The factors determining the free space-charge are considered and the resulting distribution of charge, electric field-intensity, and potential are found. (*Author's Abstract.*)

These papers were discussed by Messrs. HAWKESWORTH, WAIT, GUNN, WULF, GISH, and HUMPHREYS.

1090TH MEETING

The 1090th meeting was held in the Cosmos Club Auditorium, Saturday, November 23, 1935, President GISH presiding.

Program: K. H. BEIJ: *The National Hydraulic Laboratory and its research program.*—The National Hydraulic Laboratory was established by Act of Congress in May, 1930, and in July of the same year an appropriation of $350,000 was made for building and equipment. The building is designed to serve the three functions specified in the act of authorization: (1) determination of fundamental data, (2) study of hydraulic structures and water flow, and (3) development and testing of instruments. Facilities are provided for a maximum flow of 300 cubic feet per second, using pumps to recirculate the water. Investigations completed or in progress are hydraulics of plumbing systems, flow in pipe bends, weirs for measuring flow of streams, scour of muddy water on sandy river beds, special meters for measuring leakage

in artesian wells, flashboards for dams, etc. A special report on draft tubes has been prepared for a government agency. The laboratory edits and issues semi-annual bulletins on current hydraulic research and biennial reports describing hydraulic laboratories in the United States. (*Author's Abstract.*)

G. H. KEULEGAN: *Streamline flow in bends of large curvature.*—Previous investigators have established experimentally the relation between specific energy loss and curvature and Reynolds number for streamline flow in the downstream portion of a bend where entrance effects are not appreciable. The results of an investigation at the National Hydraulic Laboratory agree with those previously obtained. In addition, the effect of the entrance and adjustment length in the upstream portion of the bend has been determined. Also, the effect of the bend on the resistance in a straight tangent piece connected to the downstream end of the bend has been found. (*Author's Abstract.*)

These papers were discussed by Messrs. HUMPHREYS, HAWKESWORTH, DRYDEN and GISH and EATON.

1091ST MEETING

The 1091st meeting constituting the 65th annual meeting was held in the Cosmos Club Auditorium, December 7, 1935, President GISH presiding.

The treasurer reported that exclusive of liquidation of securities the income of the Society during the past fiscal year was $1478.96, the expenditures, excluding reinvestment of funds, amounted to $1283.01. Thus the ordinary income exceeded the ordinary expenditures by $195.95. Of this balance $63.75 was expended on premiums on securities purchased leaving a net balance between income and expenses of $122.20. During the fiscal year $4050.00 of the invested funds were liquidated, $3613.75 were reinvested and the investment of an additional $1000.00 was authorized by the General Committee.

The treasurer's report showed an active membership of 292 of whom 250 were in good standing.

The secretaries reported the following were elected to membership during the year: L. B. ADAMS, D. T. CLEMENTS, A. M. DU PRÉ, G. GAMOW, M. HOUSEMAN, E. G. LAPHAM, D. M. LITTLE, W. H. REYNOLDS, F. D. ROSSINI, G. SINGER, H. SONTAG, E. TELLER and J. A. SANDERSON.

The following deaths were reported: JOSEPH H. BRYAN (a member since 1886) and ERNEST G. FISCHER (a member since 1890).

The following officers were declared elected for the year 1936: *President*, F. B. SILSBEE; *Vice-President*, F. WENNER and R. E. GIBSON; *Corresponding Secretary*, F. M. DEFANDORF; *Treasurer*, W. G. BROMBACHER; and *Members-at-large of the General Committee*, L. V. BERKNER and H. F. STIMSON.

During the year the fifth Joseph Henry Lecture, in memory of the first president of the Philosophical Society, was given by P. R. HEYL.

At the conclusion of the business part of the program, Mr. L. B. TUCKERMAN presented a paper entitled *Aircraft: materials and testing.*

1092ND MEETING

The 1092nd meeting was held jointly with the Washington Academy of Sciences on Thursday, December 19, 1935, with President McCOY of the Academy presiding.

Dr. SANFORD V. LARKEY, Librarian of the Welch Memorial Library of the Johns Hopkins University, speaks on *The role of scientists in the Elizabethan government.*

1093RD MEETING

The 1093rd meeting of the Society was held in the Cosmos Club Auditorium, January 4, 1936, President SILSBEE presiding.

An address entitled *Electrical messages from the earth, their reception and interpretation* illustrated by slides, was presented by the retiring President, O. H. GISH. This address was published in this JOURNAL **26**: 267–289. 1936.

1094TH MEETING

The 1094th meeting was held in the Cosmos Club Auditorium, Saturday, January 18, 1936, President SILSBEE presiding.

The program consisted of an invited paper by Prof. R. KRONER of Freiburg, Germany, entitled *The concept of space from Aristotle to Einstein.* The paper was discussed by Messrs. HAWKESWORTH, GARNETT, DANTZIG, TUCKERMAN, and others.

1095TH MEETING

The 1095th meeting was held in the Cosmos Club Auditorium, Saturday, February 1, 1936, President SILSBEE presiding.

The sixth Joseph Henry Lecture entitled *The physical universe* was delivered by Prof. HERBERT DINGLE of the Imperial College of Science and Technology in London. This lecture which was discussed by Messrs. ABBOTT, HAWKESWORTH, SHEPARD, TELLER and TUCKERMAN was published in this JOURNAL **26**: 183–195. 1936.

An informal communication on a new consideration in the Michelson-Morley experiment was presented by P. HEYL.

1096TH MEETING

The 1096th meeting was held in the Cosmos Club Auditorium, Saturday, February 15, 1936, President SILSBEE presiding.

Program: N. SMITH: *Recent correlations of the ionosphere with sunspots and magnetic disturbances.*—More evidence has been obtained recently at the National Bureau of Standards, showing that an increase in average sunspot activity is associated with an average increase in the noon ionization density in the F_2 region of the ionosphere, and vice versa. Individual variations in the two quantities are also related to some extent.

On Sept. 25, and also on Oct. 24, 1935, the ionization density in the F_2 region remained abnormally low all day. Both of these days followed closely upon fairly severe magnetic disturbances, characterized by pronounced dips in the vertical component (Z) of the earth's magnetic field. On Oct. 24, a depression of the F critical frequency (at 1:40 A.M.) coincided with the beginning of the disturbance. The Sept. 25 disturbance took place while the average normal noon ionization density in the F_2 region was still rather low, due to the summer temperature effect and relatively low sunspot activity. The Oct. 24 disturbance took place in the midst of a period of high daytime ionization density of the F_2 region and high average sunspot activity, but during a temporary dip in the sunspot activity. The F_1 and E regions were normal on these days, and none of the regions showed excessive absorption.

A similar, but less pronounced dip in the ionization density in the F_2 region, took place on Oct. 30, when a magnetic disturbance also coincided with a period of decreased sunspot activity. On the other hand, magnetic disturbances occurring on days of great sunspot activity apparently had little effect on the ionization density in the F_2 or other regions.

A fadeout of high frequency radio signals, such as has been described by J. H. Dellinger, was recorded at the National Bureau of Standards on Dec. 23, 1935. This fadeout seemed to affect the medium high frequencies rather than the extremely high frequencies. No variation in the F_2 critical frequencies or disturbance of the earth's magnetic field was noted, and it is believed that the fadeout was entirely an absorption effect, occurring primarily in the E layer, but also affecting radio transmission by the F_2 layer. Fadeouts of this type have been correlated with the appearance of flocculi on the Sun.

High F_2 critical frequencies are normally accompanied by low F_2 layer virtual heights, and vice versa. On days of magnetic disturbances when the virtual heights were found to be greater than on normal days of about the same maximum ionization density. This may indicate that the effect of a magnetic storm is to expand the F_2 region in a manner similar to that produced by high temperatures, but in a greater degree. (*Author's Abstract.*)

E. O. Hulburt: *A theory of terrestrial-magnetic variations and of the aurora.*—Theories of terrestrial magnetic variations and the aurorae are summarized and contrasted.

The theories of the solar diurnal variation of the terrestrial magnetic field are the dynamo, the diamagnetic and the drift current theories. The dynamo theory requires an upper atmospheric conductivity greater than that at first sight indicated by present ionospheric measurements but not definitely denied by the measurements. In addition, it requires a general world wide circulation of the high atmosphere, as would be produced by horizontal winds blowing away in all directions from regions under the Sun. Such a wind system appears reasonable but it is not known to exist. The diamagnetic theory likewise requires an ionization greater than that indicated but not definitely precluded by ionospheric observation. It is simpler than the dynamo theory in that it does not require world wide winds. The drift current theory was shown to require a distribution of ionization over the earth in conflict with that calculated from the hypothesis that the cause of the ionization is the ultra-violet light of the Sun. Ionosphere data are in accord with the hypothesis.

Theories of magnetic storms and aurorae are based on the assumptions that the effects are due to streams of charged particles or ultra-violet light from the Sun. No complete charged particle theory adequate to account for the observed facts has been proposed. Various partial theories have been shown to be confronted with fundamental difficulties which they have never got around, in that the streams of particles can not carry sufficient excess charge to yield the desired bending in the terrestrial magnetic field without at the same time giving rise to forces of electrostatic repulsion sufficient to disrupt the stream during its passage from the Sun to the earth. The ultra-violet light theory appears adequate to explain the complicated storm variations of the terrestrial magnetic field, the auroral zone, the spreading of the aurora into low latitudes during strong storms, the delay of appearance of aurorae after incipience of the storm, and other observed facts. Recent ionosphere, radio, and solar eruption data have proved that the emanation from the Sun which causes the terrestrial effects travels with the velocity of light within the error of observation, and thus offer general support of the ultra-violet light hypothesis.

The recurrence of magnetic disturbance at approximately twenty-seven day intervals may be explained by the hypothesis that the emanation causing the disturbance is emitted by the Sun in narrow, less than 10°, beams which rotate with the Sun or by wide angle, 60°, puffs with the recurrence

period. The theories are equally novel in that they call for unanticipated characteristics of the solar emission, the beam theory requiring a physically strange narrow beam and the puff theory a recurrent geyser action or pulsation. Terrestrial and cometary evidence is adduced favorable to the puff theory and unfavorable to the beam theory. (*Author's Abstract.*)

These papers were discussed by Messrs. GISH, HULBURT, MARIS, WELLS, and MCNISH.

1097TH MEETING

The 1097th meeting was held jointly with the Washington Academy of Sciences on Thursday, February 19, 1936.

The meeting was addressed by W. J. HUMPHREYS on the subject *Some episodes on the pathway of meteorology*. This address has been published in this JOURNAL **26**: 435–452. 1936.

1098TH MEETING

The 1098th meeting was held in the Cosmos Club Auditorium, Saturday, February 29, 1936, President SILSBEE presiding.

Program: C. H. SWICK: *Gravity surveys of the Coast and Geodetic Survey.*—The development and use of the Brown gravity apparatus has made it possible for the Coast and Geodetic Survey to establish more than 500 gravity stations within the last four years. The advantages of the Brown apparatus are due largely to an automatic recording device and to the fact that it may be transported without removing the pendulum from the receiver. Most of the recent work of the Survey has consisted of rather intensive surveys over restricted areas and the results have been found useful in geological studies of the regions covered. A new connection with Potsdam of the Washington base station, which is now located in the Department of Commerce Building, was made in 1933. This resulted in a change of five milligals in the Washington base value and in all the gravity values previously determined in this country. The greatest present need for gravity work from the standpoint of the Survey is to complete a general survey of the United States with the stations spaced not over 30 miles apart. The principal demand for gravity work from outside the Bureau is for intensive surveys over fairly restricted areas in order that the general characteristics of the underground structure may be learned. (*Author's Abstract.*)

A. J. HASKINSON: *Tests on the new Holweck-LeJay gravity apparatus.*—The Holweck-LeJay gravity instrument which is an elastic pendulum of the inverted type, was set up at the meeting for the inspection of those present. The speaker described the mechanical construction of the instrument and compared it with the present field instruments used by the Coast and Geodetic Survey. The instruments were compared from the considerations of portability, speed of observations, and accuracy of results.

The method of making observations with the Holweck-LeJay instrument was considered in detail and the accuracy of time pieces necessary with the equipment discussed, and it was pointed out that since this instrument was about two hundred times as sensitive to gravity changes as the ordinary free swinging pendulums it was not necessary to obtain time more accurately than five hundredths of a second in determining the total time of twenty-five oscillations of the pendulum. This represents an accuracy of about one part in 2500 in the time determination.

The tests made with the instrument to determine temperature and arc constants, and to test the constancy of the elastic modulus of the spring were

discussed in considerable detail and the conclusions drawn from the tests thus far made indicate that the spring is not as constant or accurate as desired for a precise instrument but since all of these instruments so far made have improved with age it was hoped that further tests made at a later date would be more satisfactory. (*Author's Abstract.*)

W. D. LAMBERT: *The figure of the earth from gravity measurement.*—This paper will be published in this JOURNAL.

These papers were discussed by Messrs. HEYL, TUCKERMAN, SWICK, McCOMB, WENNER, and MASON.

Informal Communication: P. R. HEYL: *A new consideration of the Michelson-Morley experiment.*

1099TH MEETING

The 1099th meeting was held in the Cosmos Club Auditorium, Saturday, March 14, 1936, President SILSBEE presiding.

Program: F. WENNER: *Theory of the usual type of seismometer from the standpoint of determining ground movements from records.*

H. S. McCOMB and F. WENNER: *Shaking table investigations to teleseismic seismometers.*

F. WENNER and H. S. McCOMB: *The Gilitzin seismometer: discrepancies between the Gilitzin theory and the performance of a Wilip-Gilitzin seismometer.*

These papers were discussed by Messrs. BLAKE, McNISH and TUCKERMAN.

1100TH MEETING

The 1100th meeting was held in the Cosmos Club Auditorium, Saturday, March 28, 1936, President SILSBEE presiding.

Program: GILBERT GROSVENOR: *Stratosphere flights as exploration.*

W. G. BROMBACHER: *Stratosphere altitude, barometric and photogrammetric.*—In the flight of the stratosphere balloon *Explorer II* on November 11, 1935 piloted by Captains A. W. Stevens and O. A. Anderson, U.S.A.C., the altitude above the Earth was measured by three methods; the barometric, from vertical camera photographs, and by means of theodolites. Results from the latter method are not discussed here.

The altitude by the barometric method is given in the following formula:

$$H=221.152\ T_m\ (1+48\times 10^{-9}\ H)\ \log P_0/P.$$

Here H is the altitude, P_0 is the pressure at the ground level, P is the pressure at the upper level, T_m is the mean temperature, and the term $(1+48\times 10^{-9}\ H)$ is a correction for the variation of gravity with altitude. In computing the altitude of the gondola at any point in its flight it is important that the two air pressures and air temperature distribution be known for the air column below that point and at the particular time.

Air pressures at the level of the gondola were measured by five instruments; a meteorograph hung 10 meters below the gondola, two barographs installed on top of the gondola, an aneroid barometer, and a mercurial barometer the latter two of which were photographed at intervals of 90 seconds during the flight. The aneroid barometer is one of two instruments especially constructed for use in this flight and was primarily relied upon for the air pressure at the upper level. Its pressure range is from zero to 800 mm of mercury with a pointer travel of eight revolutions.

The air temperatures were measured by means of a resistance thermometer of the unbalanced Wheatstone bridge type. The resistance element was mounted on an arm at a distance of about 10.5 feet from the gondola wall.

The air pressure and air temperature at the surface were obtained by interpolation from readings taken hourly during the flight by a net of 12 stations of the U. S. Weather Bureau.

Using the data obtained as mentioned above, the altitude above sea level was computed by the barometric formula for 312 positions of the balloon.

In principle the determination of altitude from the vertical camera photographs is simple. The following relation is used:

$$H = fD/d.$$

The equivalent focal length f (258.2 mm) was measured before the flight. The distance d between two landmarks such as section and township lines were measured on plate prints of the flight films and the corresponding distance D on the ground was obtained from the General Land Office. A number of the pictures at the highest altitude had points for which the Coast and Geoetic Survey was able to furnish the elevation above sea level. The ground data readily available were adequate for obtaining altitudes above sea level.

The principal correction to be applied is that for the effect of tilt of the camera. This did not exceed three degrees of arc.

The results of 60 comparisons of altitude by the two methods (not available at the time of the delivery of the paper) show that the difference in the altitudes without regard to sign is 0.36 per cent and that on the average the barometric altitude is 93 feet less than that from the photographs. The uncertainty in the determinations is estimated to be 0.25 per cent. (*Author's Abstract.*)

H. W. HEMPLE: *Trigonometric stratosphere altitude and position.*—The Coast and Geodetic Survey organized a body of voluntary observers who obtained horizontal and vertical angle measurements on the stratosphere balloon, with surveyors transits from triangulation stations whose latitude, longitude, elevation above mean sea level, and azimuth to another mark were known. The observations were made at 15 minute intervals. An attempt was made to obtain simultaneity of pointings from the various triangulation stations, by taking the observations at the word cue announcements broadcast by certain commercial radio stations. These signals were picked up at each station by ordinary automobile radio receiving sets. The resulting data enabled the horizontal position and elevation of the balloon to be computed by means of trigonometric formulae. The difference between the elevations obtained trigonometrically and those determined from the barograph readings is 0.58 per cent. The average of these differences without regard to sign is 154 feet, the vertical angle determinations being the lower. The horizontal rate of travel varied from 30 to 54 miles per hour. The average length of sight from the observers to the balloon was 60 miles. The longest line over which the balloon was seen was 198 miles. The maximum velocity during the descent was 827 feet per minute, as averaged for 15 minute intervals. The difficulties of computation of the results, due to the deflection of the vertical, introduce errors which in comparison with the accuracy obtained with the instruments used, are so small that they may be ignored. Refraction also presents difficulties in the determination of altitude by vertical angle observations. The formula used involves the coefficient of refraction, which takes account of the curvature of the line of sight. Arbitrary assumptions for this coefficient varying from 0.06 at an elevation of 6,000 feet to 0.038 at elevations of 70,000 feet and above, were used. A more rigorous determination of the coefficient of refraction could be made, but this

would involve a tedious, time-consuming, numerical integration. The discrepancies in the observations obtained do not warrant such intensive study, and the results as determined should be considered experimental only. In any future flight, the lessons learned on this flight, may be put to good account should this feature of the flight be desirable. (*Author's Abstract.*)

G. M. Shepherd: *The composition of the stratosphere.*—Calculated values for the composition of air at great heights were discussed. Previous work was reported. Several forms of sampling apparatus used during the flight of the *Explorer II* were described. Preliminary results obtained with the samples secured indicated a very slight lowering of the oxygen content. Nearly 300 parts per million of helium was found and interpreted as contamination from the balloon. The change in composition would indicate that separation might have started at about 21 kilometers, instead of 11 kilometers as the classical theory had supposed. (*Author's Abstract.*)

O. H. Gish: *The electrical conductivity of the stratosphere.*—Satisfactory registration of the electrical conductivity of air was made throughout the flight of *Explorer II* with apparatus designed and constructed at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The record obtained shows that the air-conductivity in general increased with altitude, the highest value, which was recorded at 18 kilometers (60,000 ft.) altitude, was about 100 times the average value observed on the *Carnegie* at the surface over the oceans. The values recorded on the ascent were generally less than those found on the descent probably because dust or other "polluting" substances given off by the balloon affected the "sample" of air on the ascent but not on the descent because when ascending the gondola was running into air which had been adjacent to the balloon whereas it was running away from it on the descent.

Positive-ion conductivity was always less than that for negative ions, except for one spurious negative conductivity group at the *top*, and contrary to expectation, the negative conductivity at the high levels, or low pressures, did not increase relative to the positive conductivity of corresponding level. This leads one either to question the rapid increase of negative mobility reported from laboratory experiments at low pressures or else to conclude that this is an indication that probably more water vapor exists in the high atmosphere than is generally expected, because the abnormal increase of negative mobility is said to be less marked when small quantities of water vapor are present.

An estimate of the potential difference (voltage) between the earth and high atmosphere, based on the conductivity data and on measurements of air-earth current made at the earth's surface, indicates that the highly conducting region of the atmosphere is at about 400,000 volts higher potential than the earth. Nearly half of this increase occurs in the lower 2 kilometers.

Throughout most of the region where the conductivity was measured the cosmic radiation is doubtless the predominant ionizing agent, hence calculations were made of the conductivity to be expected from observed cosmic radiation intensities. The values calculated from Regener's cosmic-ray data, using generally accepted relations, were all greater than corresponding observed values. The ratio of the calculated values to those observed on the descent increases regularly in the region from 6 to 18 kilometers altitude. This, together with other circumstances, led to the surmise that the recombination coefficient for small ions varies, not as the first power of the pressure but more nearly as the one-half power. With such an adjustment the

calculated and observed values are in excellent agreement throughout the 12 kilometers of altitude from 6 to 18 kilometers.

Lack of agreement in the lower atmosphere was expected, chiefly because of the presence there of condensation nuclei. The distribution of these is derived from the difference between calculated and observed conductivity. If the data for altitudes from 18 to 22 kilometers are interpreted in a similar manner, a surprising conclusion is reached, namely, that the air in this high stratum contained several thousand nuclei per cubic centimeter. However, from the fact that mother-of-pearl clouds have been frequently observed at this level one may infer that nuclei are not uncommon at such levels. (*Author's Abstract.*)

L. B. TUCKERMAN: *Strength and performance of stratosphere balloons.*—The strength of stratosphere balloons under flight conditions can readily be calculated and ample factors of safety for these conditions can be provided. The problem is to insure that the stresses in the envelope of the balloon will at no time exceed a value which the balloon fabric can support with safety. Equations for estimating these stresses for a balloon with a uniform fabric envelope both at take-off and in the air were presented. The stresses so obtained have to be increased considerably to allow for the stress concentrations around local reinforcements such as those lining the rip panel. The formulas become very cumbersome for this case and it is preferable to resort to tests for an answer. The tests made for this purpose on the rip panel first used in the *Explorer II* were described and were illustrated by slides.

The principal problems in considering the performance of a stratosphere balloon are to estimate the ceiling of the balloon with a given amount of ballast and to estimate the optimum amount of ballast to be carried along. An optimum exists since the ballast must be sufficient to allow for a safe descent and yet it should be kept to a minimum in order to let the balloon attain a maximum altitude. Particular attention must be paid to the effect on the performance of the superheat that is due to the absorption of solar radiation by the balloon gas. Superheat lowers the density of the gas and therefore leads to a rise of the balloon. It also expels gas through the appendices and in that way increases the amount of ballast required to check the fall of the balloon during its descent into the cooler and denser air nearer the Earth. Curves and equations illustrating these effects of superheat were shown. (*Author's Abstract.*)

1101ST MEETING

The 1101st meeting was held in the Cosmos Club Auditorium, Saturday, April 11, 1936, President SILSBEE presiding.

Program: E. C. CRITTENDEN: *New international actions on electrical units.*—When the electrical units now in use, called "International," were adopted, it was considered necessary to have them represented by standards which could be set up independently in any well-equipped laboratory. Consequently the ohm was defined as the resistance of a specified column of mercury, and the ampere as the current which deposits silver at a certain rate from a silver nitrate solution under specified conditions. Other units were derived from these two. In actual practice, however, the ohm and volt as established in 1910 have been maintained by resistance coils and standard cells, and practically no one has gone back to the primary standards.

A treaty signed in 1921 and made effective in 1927 gave the International Committee on Weights and Measure jurisdiction over electrical units. In 1929 the Committee decided that the practical electrical units should be

revised to make them concordant with the fundamental mechanical units. As a basis for this revision new absolute determinations of the values of the units were necessary. In 1933, although results of the determinations were not ready, the General Conference on Weights and Measures confirmed the plan of changing from the "international" to absolute units. It authorized the International Committee to fix the values of the new units and the date at which they should be adopted.

The International Committee has laid out a definite program for the introduction of the new units. First, a technical sub-committee will consider the relative reliability of different determinations and will assign to groups of resistance coils and standard cells the values which seem best to represent the combined results of absolute measurements before the end of 1938. Values for the units are then to be certified to the governments of the different countries not later than March 1939. The new units are to be introduced into actual use on January 1, 1940, and shall hold for a period of at least 6 years from that date.

It is expected that the absolute values will be uncertain by a few parts in 100,000, but values for the practical reference standards will be assigned to a part in 1,000,000. In other words, uniformity between countries to a few parts in 1,000,000 will be sought, although the absolute values will be subject to an uncertainty of ten times that magnitude. The change from the present basis will be radical in principle, but the change in magnitude of the units will not be great enough to trouble any one except laboratories making precise measurements, since the largest adjustment necessary will be 1/20 of one per cent. (*Author's Abstract.*)

H. L. CURTIS: *Principles involved in the establishment of electrical units by absolute measure.*—The method of establishing the electromagnetic units from the mechanical units was reviewed. The electrical unit most readily established is that of current, which is determined from the mechanical force between two conductors, each carrying the same current. The second unit of the system is electromotive force, which is defined as the rate at which energy is transformed in a circuit into, or from, electric energy when there is unit current in the circuit. There are only two forms of energy into which electrical energy can be completely transformed, viz, heat energy and magnetic energy. If the transformation between electric and magnetic energy is employed, the equation for the energy can be so combined with the equation expressing Ohm's law, that there results an equation which gives a relation between a resistance and mechanical quantities. In this manner, the unit of resistance is determined by absolute measurements instead of the unit of electromotive force. When units of current and resistance have been established, the unit of electromotive force is determined as the potential difference between the terminals of a unit resistance through which there is unit current. (*Author's Abstract.*)

CHARLES MOON: *Determination of the ohm in absolute measure.*—The value of the absolute ohm has been determined from the mean solar second and the absolute henry. The mean solar second depended on the time signals of the U. S. Naval Observatory, and the absolute henry depended on the computed self-inductance of helices wound on nonmagnetic forms. The time signals were used to calibrate a piezoelectric oscillator which controlled a 100-c/s generator. The self-inductance was computed for three inductors which had different dimensions and were wound on forms of different materials, namely, porcelain, pyrex glass, and fused quartz. The electrical measurements called for an intermediary capacitance, so that a resistance was

first measured in terms of inductance and capacitance by an alternating-current bridge, then the capacitance was measured in terms of resistance and time by the charge and discharge method of a Maxwell bridge. Assuming that the capacitance was the same under the two conditions stated, it was eliminated between the two bridge equations.

The result of the measurements on these inductors is: 1 NBS International Ohm = 1.000450 Absolute Ohms. This result probably differs from the true value by less than 20 parts in a million. The greatest uncertainty arises from irregularities in the pitch of the winding.

R. W. CURTIS: *Determination of the ampere in absolute measure.*—The method of determining the ampere in absolute measure by means of the current balance was described at the 1042nd meeting of the Society on October 22, 1932 (See abstract in this JOURNAL **23**: 157. 1933). This method was reviewed and the progress made since that time reported.

Two different types of coils for use as moving coils in the current balance have been constructed recently. One type of coil is a short, single-layer solenoid wound on a threaded *Pyrex* glass form. This gives a coil of 41 turns and 1 layer. The other type of coil (described in an informal communication by H. L. CURTIS at the 1071st meeting, May 26, 1934, this JOURNAL **24**: 563. 1934) was constructed from insulated aluminum strip wound on an aluminum form in a *watch spring* or *pan cake* spiral coil, which resulted in a coil of 1 turn per layer and 45 layers. The important feature of both of these types of coils is that their cross-sectional dimensions can be accurately measured after winding.

Preliminary results, obtained by using the short solenoid, were reported. They indicate that the ratio of the NBS International Ampere to the Absolute Ampere is somewhat smaller than previously reported. An analysis of this latest result with the older data indicates that all of the results may be made more consistent by the assumption of certain reasonable errors in the cross-sectional dimensions used for some of the older coils. (*Author's Abstract.*)

These papers were discussed by Messrs. MCNISH, HAWKESWORTH, WHITE, R. W. CURTIS, DRYDEN, BUCKINGHAM, and ELLIS JOHNSON.

1102ND MEETING

The 1102nd meeting was held in the Cosmos Club Auditorium, Saturday, April 25, 1936, Vice-President WENNER presiding.

Program: R. J. SEEGER: *Theories of the electron.*

Discussed by Messrs. MCNISH, BRICKWEDDE and TUCKERMAN.

F. L. MOHLER: *Vertical distribution of ozone from the spectroscopic results of the stratosphere flight.*—The spectrographic program of the stratosphere flight was a joint project of Dr. Brian O'Brien of Rochester University and the author. Two quartz spectrographs automatically photographed ultraviolet spectra of the sunlight and the skylight throughout the flight. Results of the sunlight spectra were reported. An optical wedge of evaporated aluminum over the slit of the spectrograph gives a basis for measuring the relative intensity of wave lengths within the ozone band (3110 A to 2992 A) and outside the band (3300 A). The change in the relative intensity at a constant altitude and changing zenith distance of the sun gives the amount of ozone above that altitude. The amount above 5 km was equivalent to 0.18 cm at normal pressure and temperature. The change in relative intensity with altitude corrected for changing zenith distance gives the vertical distribution. The amount of ozone above the balloon did not change ap-

preciably below 16 km. Between 16 and 22 km there was a rapid change of over 20 per cent. The amount of ozone above 22 km was equivalent to 0.145 cm. The change is much more abrupt than that found by Regener. (Phys. Zeits. **35**: 788. 1934) and by Goetz, Dobson and Meetham (Proc. Roy. Soc. **145**: 149. 1934). (*Author's Abstract.*)

Discussed by Messrs. GISH, BROMBACHER, HAWKESWORTH, BRICKWEDDE, and TUCKERMAN.

1103RD MEETING

The 1103rd meeting was held in the Cosmos Club Auditorium, Saturday, May 9, President SILSBEE presiding.

Program: E. TELLER: *A report on the Second Washington Conference on Theoretical Physics held jointly by the George Washington University and the Carnegie Institution of Washington.*—The subject of the second conference was *Molecular physics,* that is, the part of physics which constitutes the link between physics and chemistry.

The differential equations of quantum mechanics contain in principle the complete solution of all problems of chemistry. In practice, however, these solutions can not be carried out because the mathematical difficulties are too great. Recourse has to be taken to more or less rough approximations, and, also, to the procedure of evaluating only part of the problem and relying for the rest on direct experimental evidence. The subjects discussed and the principle conclusions were as follows:

The chemical bond.—The important thing realized was the necessity of bringing closer together the empirical facts of chemistry and the mathematical methods of approximation of the physicist.

Theory of reaction velocities.—It was made clear what assumptions are involved if one tries to attack the problem of reaction velocities by discussing in detail an intermediate system (activated complex) which is formed by the original molecules and then disintegrates into the reaction products, the concentration of which determines the speed of the reaction.

Excited electronic states in crystals.—During discussions of spectra of crystals, internal photo-effects, and other phenomena in which excitation of electrons is involved, the striking difference between the behavior of electrons in crystals and in atoms was brought out. This difference consists in a more intimate connection between the electronic excitation and the displacement of the heavy particles within the crystal. The motion of the heavy particles becomes particularly important if the symmetry of the crystal is thereby destroyed.

Paramagnetism of the rare earths.—The coupling between electronic and nuclear motion becomes important if one wants to utilize the spectra of the rare earths in order to interpret their magnetic behavior. Contradictions which appear to arise between the greater number of low energy levels found in the spectra and the smaller number predicted from magnetic measurements are eliminated if the crystal vibrations are taken into account.

Ferromagnetism.—A new model with the help of which both ferromagnetism and electrical conductivity may be explained was discussed. Hitherto different models were used to explain the two phenomena which was not satisfactory since most of the ferromagnets are conductors.

Isotopic effect.—The question was discussed to what extent the forces acting on the nuclei remain the same during an isotopic substitution.

Molecular vibrations.—For harmonic forces the problem of molecular vibrations may be regarded as solved in principle. For unharmonic forces

some contradictions the clarification of which is urgently needed were pointed out.

Summing up the results of the conference, it can be said that from the discussion of these divergent topics one general impression has emerged. Though the final unification of physics and chemistry is at present only a hope for the distant future at least the difficulties which the physicist meets if he tries to attack the problems common to chemistry and physics are clearly seen and formulated. (*Author's Abstract.*)

Discussed by Messrs. GIBSON, KRACEK, CURTIS and others.

1104TH MEETING

The 1104th meeting was held in the Cosmos Club Auditorium, Saturday, May 23, 1936, President SILSBEE presiding.

Program: A. S. HAWKESWORTH: *Stellar distances and the expanding universe.*—Even as a thing must exist, or be in time, before it can occupy a place in space, so also must two or more things be contemporaneous, or co-exist in the same instant, before there can be any spatial relations between them of distance or of relative movements. Hence, due to their vast time differences, we cannot tell the distances of stars and nebulae from each other or from us. And assuredly they have no such contemporaneous *whole* such as an *expanding universe* would demand, nor can we state the size of our galaxy or of any other nebula. The *light years* values we deduce for the various stars and nebulae simply means that, say, 100 years ago a certain star was blazing the equivalent number of miles or kilometers from the point where we are now. But the star is not there now and 100 years ago we were not at our present position so that light years can never be interpreted as distance from the star. The origin of the blunder of measuring star distances is the fact that constant and invariable experience in daily life has impressed on our sub-conscious minds the assumption that light is instantaneous and that what we see now exists now, an illusion that is pragmatically true and works in daily life but is wholly false and misleading in the vast abysses of space where the finite, although still high, velocity of light is of paramount importance. Thus those stars and nebulae we see, not as they are now, but as they once were in long past and isolated disjunctive instants. Hence, as stated, it is folly to endeavor to measure their distances or relative movements. (*Author's Abstract.*)

H. K. SKRAMSTEAD: *Primary ionization by high energy electrons in nitrogen and neon.*—A large expansion chamber in a magnetic field of about 400 gauss was used to study the tracks of high energy electrons produced by bombarding a lead screen inside the chamber by gamma radiation from radon. Two photographs at right angles were taken and the tracks examined by projection on a screen in their original configuration. Measurements were made of the number of primary ions per centimeter path produced in nitrogen and neon. The results in nitrogen can be expressed approximately by the relation:

$$I = 19\beta - (1.15 \pm .15)$$

and in neon by the relation:

$$I = 12.6\beta - (1.35 \pm .15)$$

where I is the primary ionization in ions per cm at normal temperature and pressure, and β is the velocity of the beta ray in units of the velocity of light.

Measurements on a few tracks in oxygen agreed within experimental error with the results of Williams and Terroux. The primary ionization of the

positive electrons observed was indistinguishable from that of the negative electrons. Comparisons were made with the theoretical calculations of Bethe, Moller, and Williams, and the agreement is excellent over the range of velocities used.

The magnitude obtained for the primary ionization in nitrogen corresponds to an average ionization potential of 16.6 volts for the five outer electrons in the nitrogen atom, which is very near its minimum ionization potential. Theoretical calculations were made for neon, using ionization potentials for each electron calculated from critical absorption wave-lengths. The experimental results are about 12 per cent greater than those calculated from the theory, and are thus in substantial agreement.

The variation of primary ionization with velocity checks well for values of β less than .97, but the predicted increase for very high energies is not observed. (*Author's Abstract.*)

A. G. McNish: *The Stewart-Shuster theory of terrestrial magnetic variations.*

These papers were discussed by Messrs. Heyl, Humphreys, Tuckerman, Gish, and Silsbee.

L. R. Hafstad, *Recording Secretary*

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JOURNAL
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WASHINGTON ACADEMY OF SCIENCES

VOL. 26 DECEMBER 15, 1936 No. 12

GEOPHYSICS.—*The figure of the earth from gravity observations.*[1]

WALTER D. LAMBERT, U. S. Coast and Geodetic Survey.

This is to be mainly a theoretical and historical treatment based on the work of three outstanding men, with some recent work of the Coast and Geodetic Survey in the preparation of certain tables coming in at the end, not as an intentional anti-climax but simply because it is latest in time.

By *figure* we may mean: (1) the general figure, the flattening of the oblate terrestrial spheroid; or we may mean (2) the figure in detail, that is, how much the geoid, or sea-level surface, deviates in this region and in that from the smooth mathematical spheroid of closest fit. The problem of the general figure of the earth will be discussed in connection with the names of two of the greatest contributors to its solution, Isaac Newton and Alexis Claude Clairaut; the problem of the detailed figure of the earth in connection with the name of George Gabriel Stokes.

NEWTON

Let us consider what was known about the figure of the earth at the time when the first edition of Newton's *Principia* appeared in 1686. Norwood about fifty years earlier had determined the length of a degree of the meridian by finding the distance between London and York; Picard in France had measured the meridional distance between Paris and Amiens and it was the length of a degree determined from Picard's work that Newton used in the first edition.[2] The

[1] Presented at the meeting of the Philosophical Society held February 29, 1936. Received June 19, 1936.

[2] The upper left-hand portrait of Fig. 1 comes ultimately from a volume in the Pepys Library at Cambridge, England. It is here reproduced by permission from Cajori's edition of the *Principia*, Sir Isaac Newton's *Mathematical principles of natural philosophy and his system of the world*, translated into English by Andrew Motte in 1729. The translation was revised, and supplied with a historical and explanatory appendix by Florian Cajori (published by the University of California Press in 1934). "In assigning, therefore, the date of this portrait to a period a few years on either side of 1691, we shall not perhaps be very wide of the truth. If this supposition be well-founded, this portrait may be considered as the most interesting of all the known portraits of our philosopher, as representing him at a time of life least remote from those memorable eighteen months which it cost him to produce the great work that immortalized his name." (Quoted on p. 627 of Cajori's edition from Edleston's *Correspondence of Sir Isaac Newton and Professor Cotes.*)

Fig. 1.—*Upper left:* Isaac Newton about 1691. *Upper right:* Isaac Newton in later life. *Lower left:* Alexis Claude Clairaut. *Lower right:* George Gabriel Stokes.

work of the Cassinis, father and son, which seemed to show a shortening of the degree of the latitude as the pole is approached and hence a prolate terrestrial ellipsoid instead of an oblate one, thus giving rise to prolonged controversy, was not yet completed. The third edi-

tion of the *Principia* appeared shortly before Newton's death[3] and after Cassini, the younger, had completed his work and announced that it showed the earth to be prolate. In this third edition Newton omitted the reference to the work of the Cassinis that he had made in the second edition, and simply hurdled over the difficulty, taking an average degree based on their arc extending across France from near the Spanish frontier to the English Channel.

With this approximate knowledge of its size Newton went on to consider its shape considered as a rotating fluid. The principles of hydrostatics were as yet undeveloped; the potential function had not been heard of; the differential and integral calculus was in a rudimentary state and Newton felt constrained to avoid in print the analytical methods that we now know him to have used for his own enlightenment.

He had obtained exact expressions for the attractions of certain bodies, especially for the attraction of figures of rotation on points in the axis. These are familiar when we penetrate the disguise of his form of statement. He also states the result for a point on the axis of an ellipsoid of revolution. How he performed the rather involved integration, or its equivalent, does not appear.

With this equipment he tackles the problem of the figure of the earth considered as a mass of rotating homogeneous fluid. In his diagram[4] PCQ, not ACB, is the polar axis. Imagine the mass solidified except for ACac and CQcq, which are small canals from the center to the equator and to the pole. A necessary condition for equilibrium is that the fluid in these canals shall balance at the center, allowing for the difference of attraction of the ellipsoidal mass in the two directions and for the centrifugal force along the canal CA. Bear in mind that there was no science of hydromechanics, no word or precise concept for the pressure of a fluid. Newton has no trouble with the centrifugal force; he has an exact expression for the attraction at Q, a point on the axis of rotation. The attraction at the point A on the equator bothers him somewhat. We now know that this attraction can be expressed by integration in terms of the elementary functions. Newton finds an ingenious approximation valid to the first power of the flattening.

Daniel Bernoulli, surely no mean mathematician, writing fifty years after Newton, finds an expression equivalent to Newton's, notes

[3] The upper right-hand portrait shows Newton, evidently in his later years as painted by Sir Godfrey Kneller. Reproduced from a picture furnished by the Library of Congress. Kneller died before Newton, so the portrait can not represent Newton toward the very end of his life, when the third edition appeared.

[4] Upper left-hand diagram of Fig. 2. Reproduced from Le Seur and Jacquier's edition of the *Principia*, Cologne, 1760. Book III, Prop. XX, Problem IV.

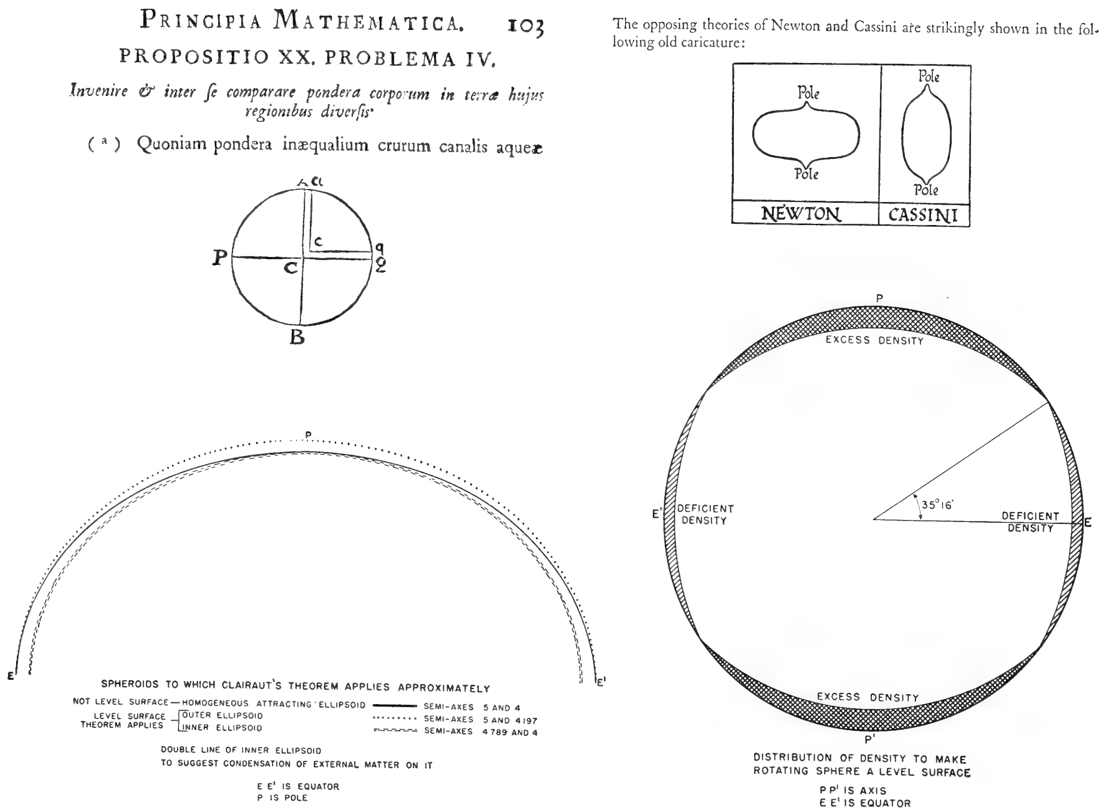


Fig. 2.—*Upper left:* Newton's canals. *Upper right:* An eighteenth-century caricature of the dispute concerning the figure of the earth. *Lower left:* Spheroids to which Clairaut's theorem applies. *Lower right:* The sphere as a level surface subject to Clairaut's theorem.

the fact and says: "As to this [Newton's] reasoning, perhaps only he himself could see his way through it, for this great man was able to see even through a veil, what another man scarcely discerns with a microscope."[5]

This particular passage is undoubtedly condensed and difficult, but Bernoulli to the contrary notwithstanding, with the aid of the *Principia* itself, Le Seur and Jacquier's useful commentary and Todhunter's[6] explanations it is possible to follow the train of Newton's thought. And Newton's comes out right in the end. If the earth were homogeneous, its flattening would be 1/230. This value is five-fourths of the ratio of the centrifugal force at the equator to gravity; this ratio is frequently denoted by m. The flattening of a homogeneous ellipsoid rotating with the speed of the earth is then $(5/4)m$. This is essentially the same result as would be reached with modern data by the help of modern mathematics. The earth is, of course, not quite so much flattened as this. Newton does not consider what would happen at points between the pole and the equator, nor does he show—what is true—that under the assumed conditions of homogeneity and fluidity the figure would be an exact ellipsoid.

For a test of his theory, Newton looked to pendulum observations, ignoring, as we have noted, measurements of meridional arcs. Astronomers going to the tropics had noticed that their clocks, carefully rated for some northern observatory, needed to have their pendulums shortened in order to keep time in the new location. Gravity, as he knew, would vary in this case between pole and equator as the square of the sine of the latitude. On this basis and with a flattening of 1/230, Newton prepared a table for various latitudes based on length of the second's pendulum in Paris[7] and compared it with the length found in the tropics.

For the first edition he had three observations; Cayenne in Guiana, St. Helena, and Goree near Cape Verde in Africa. For the third edition he had also Lisbon and Paraiba in Brazil, also various places in the *Spanish Main.* The places were near the coast and the reductions to sea level to make them comparable were perhaps small; Newton

[5] *Traité sur le flux et reflux de la mer.* Chapter II, Section VIII. Reproduced in Le Seur and Jacquier's edition of the *Principia*, Cologne, 1760, Vol. III, p. 146.

[6] *A history of the mathematical theories of attraction and of the figure of the earth*, Vol. I, pp. 9–17.

[7] This is given as 3 (Paris) feet 8.555 lines, equal to 99.382 cm. The modern value is 99.390 cm. The *hexapeda* of the table of lengths of degrees is the *toise.* Writers who use an ancient language, like the Latin, for modern purposes are obliged to use words "that would have made Quintilian stare and gasp." The toise was six Paris feet and was equal to 1.949 meters, or 6.394 U.S. feet. The Paris foot was divided into twelve inches and the inch into twelve lines. In the table of lengths of the seconds pendulum the inch does not appear, as it happens to be zero for all latitudes.

mentions the heights[8] of the mountains as possibly affecting the results, but applies no correction for this, although he does calculate the correction to the length of the Paris pendulum for the buoyancy of the air. The best that he can do for the temperature correction is to quote observations of Picard on the difference in length of an iron rod at freezing temperature and when heated and other observations

TABLE 1.—NEWTON'S TABLE OF LENGTHS OF THE SECOND'S PENDULUM AND MERIDIONAL ARCS OF 1 DEGREE.

Latitudo loci grad.	Longitudo penduli ped.	lin.	Mensura gradus uniús in meridiano hexapedæ
0	3	7.468	56637
5	3	7.482	56642
10	3	7.526	56659
15	3	7.596	56687
20	3	7.692	56724
25	3	7.812	56769
30	3	7.948	56823
35	3	8.099	56882
40	3	8.261	56945
41	3	8.294	56958
42	3	8.327	56971
43	3	8.361	56984
44	3	8.394	56997
45	3	8.428	57010
46	3	8.461	57022
47	3	8.494	57035
48	3	8.528	57048
49	3	8.561	57061
50	3	8.594	57074
55	3	8.756	57137
60	3	8.907	57196
65	3	9.044	57250
70	3	9.162	57295
75	3	9.258	57332
80	3	9.329	57360
85	3	9.372	57377
90	3	9.387	57382

of de la Hire, and apparently of himself also, on the difference due to summer and winter temperatures; it is all as vague as that, although observations on the coefficient of expansion made with real thermometers not long after the appearance of the third edition of the *Principia* are noted by Le Seur and Jacquier. Newton discusses very sensibly the correction to be applied under working conditions and by correcting for temperature Richer's result, which he considers to

[8] To Newton's commentators, Fathers Le Seur and Jacquier, the effect of mountains and valleys appears as due solely to added or deficient matter. They do not see the necessity of reducing to a level surface, the idea of which was of course in the future. Their second edition (published in their lifetime) appeared after Clairaut had introduced the notion of level surfaces and Bouguer had corrected the values of gravity for elevation, but no mention of these ideas appears even in the second edition. Perhaps Newton was of the same mind with his commentators. His reference to mountains is very brief.

be based on the longest and most careful set of observations, he concludes that Richer's work bears out his theoretical flattening of 1/230. Hence the earth is, as he says, 17 miles, 3923.16/230, "higher" at the equator than at the poles, that is, the equatorial radius is 17 miles longer.

The observations with pendulum clocks other than Richer's give a greater excess of gravity at the pole over gravity[9] at the equator and hence, says Newton, the earth may be even *higher* at the equator than he had calculated for a homogeneous earth, that is, the equatorial radius is longer and the flattening greater than 1/230, instead of less, as we now know it to be.

This was a natural error. His commentators, Le Seur and Jacquier, accept it and the statement seems self-evident at first thought. Men of scientific standing fall into this trap once in a while even to this day. The flattening causes the difference in gravity between equator and pole. The greater the flattening, the greater this difference in gravity must be. But this is incorrect, as is proved by Clairaut's theorem, which at first seems like a paradox. The seeming paradox is easily explained and will be mentioned in connection with Clairaut. It is only fair to Newton, however, to add that in his third edition he suppressed one reference to this notion, as if his second thoughts seemed better than his first; but other passages implying the same idea remain unchanged from earlier editions.

Newton made one suggestion, however, to which no exception can be taken. He pointed out that greater density towards the center as compared with the surface would tend to increase the difference in gravity between pole and equator.

CLAIRAUT

Alex Claude Clairaut was born in Paris in 1713. His father was a teacher of mathematics and the son showed mathematical genius very early. When Clairaut was only twelve he read before the Paris Academy a memoir on four new curves discovered by him; when sixteen he published a memoir on space curves and when eighteen he was accepted as a member of the Paris Academy, although he was three years below the statutory age.[10]

Shortly afterwards he began working at problems in geodesy and

[9] Newton uses the *length of the seconds pendulum* as a measure of gravity, but *gravity* is a shorter expression and is therefore used here.

[10] The portrait of Clairaut (lower left-hand corner of Fig. 1) is reproduced from a German translation (with commentary by Jourdain and von Oettinger) of Clairaut's *Théorie de la figure de la terre*, etc., published as no. 189 of Ostwald's *Klassiker der exakten Wissenschaften.* The ultimate source of the portrait and the age of the subject are not given.

the equilibrium of fluids and publishing his results, but the work with which we are chiefly concerned did not appear till after his return from Lapland. He went there at the age of 23 as a member of a geodetic expedition headed by his friend, Maupertuis. The purpose of the expedition was to settle the question raised by the Cassinis on the basis of arc measurements in France, as to whether the earth was flattened or elongated at the poles. The work of the Cassinis was too inaccurate and covered too small a range of latitude to be conclusive, but their opinion that observation showed the earth to be prolate had for years divided the learned world into two opposing camps.[11] The meridional arc in Lapland settled the question, in fact it seemed to make the earth much flatter than it really is and Maupertuis was proclaimed by Voltaire "the flattener-out of the world and of Cassini." Voltaire, however, wrote also a poem in which he says of Maupertuis:

> You, choosing mid these frozen wastes to roam
> Confirmed what Newton found, who stayed at home.[12]

Maupertuis had confirmed Newton by observation. His follower, Chairaut, returning from the cold and mosquitoes of Lapland, took up the problem theoretically and partly confirmed Newton, partly corrected him. He published at the age of thirty his *Theory of the figure of the earth derived from the principles of hydrostatics*. The earlier chapters are largely devoted to mathematical discussions intended to refute the ideas of the Cartesian school of phisosophy, which believed in definite centers of attraction; this part is of comparatively little interest to us today.

In Chapter five Clairaut brings in the idea of a "level surface," which he calls "surface courbe de niveau." Maclaurin just one year before had spoken of level surfaces under exactly that name but Clairaut gave the condition for a level surface, namely in Cartesian coordinates that

$$Xdx+Ydy+Zdz$$

shall be a perfect differential, where X, Y, and Z are the components

[11] An eighteenth century caricature showing the views of the two opposing schools of thought regarding the figure of the earth is shown in the upper left-hand part of Fig. 2. The protuberance at the pole in both cases is doubtless the idea of the caricaturist, not that of either school of geodesy. Perhaps the caricaturist conceived the earth as revolving on a physical axle. Reproduced by permission from Cajori's edition of the *Principia* already referred to.

[12] "Vous avez confirmé dans ces lieux pleins d'ennui
Ce que Newton connut sans sortir de chez lui."

Voltaire. *Quatrième discours. De la modération en tout.* These verses do not appear in the first edition, which was more complimentary to Maupertuis. Perhaps another reason for changing the first edition was that it states that in *Lapland* the night is six months long (Où les rayons du jour sont six mois éclipsés).

of a force. The function of which this quantity is the differential, namely the potential, as we now call it, is not explicitly introduced, nor does the concept of level surface appear except in connection with the hydrostatic problem in hand. The introduction of the potential as an independent concept came about forty years later and the name was not introduced until 1828, when George Green chose it. Clairaut also states the test for deciding whether a given expression is a complete differential or not.

Clairaut determines the condition of equilibrium of a homogeneous spheroid accurate to powers of the flattening higher than the first, the point at which Newton stopped, proves that the spheroid is an exact ellipsoid and then goes on to discuss the attraction of heterogeneous spheroids; here his theorems are accurate only to the first power of the flattening. He considers both the case where the interior of the spheroid is in hydrostatic equilibrium and the case where it is not necessarily so. If we make no supposition about the interior but assume the outer surface is a level surface of small ellipticity under the influence of self-attraction and rotation—a surface like that of an ocean covering the whole earth—then we have Clairaut's theorem. This may be stated thus: Let g_p and g_e be gravity at the poles and equator of such a surface, f its ellipticity or flattening and let m be the ratio of the centrifugal force at the equator to gravity at the equator; then

$$\frac{g_p - g_e}{g_e} = \frac{5}{2}m - f.$$

For a given angular velocity and a given mass, m is nearly constant, so that the flattening, f, and the difference of gravity between pole and equator, $g_p - g_e$, vary in opposite directions because of the negative sign before f. When one increases the other decreases. Since the ellipticity is the cause of the difference in gravity, or *vice versa*, this seems paradoxical and it is the reverse of what Newton stated and his contemporaries accepted, at least when Newton was preparing the first two editions of his *Principia*. It is not clear even in his third edition that he had definitely changed his view.

One way of reconciling oneself to the seeming paradox is to remember that Clairaut's theorem applies to a level surface enveloping all attracting matter. Take a very flattened ellipsoid such as is shown in the lower left-hand corner of Fig. 2, which is not a figure of fluid equilibrium and therefore keeps its form because of its solidity. The theorem does not apply to the physical surface of such an ellipsoid.

It would apply to a level surface enveloping it, the ellipsoid indicated by the outer dotted line. It would apply also after a fashion to an inner level surface, if gravity were reduced to such a surface by the free-air reduction; that is, reduced to a smaller distance from the center in low latitudes, the distance through which the free-air reduction must be made to increase as the equator is approached. The theory behind the free-air reduction implies a condensation of matter external to the level surface upon that surface as a surface layer—that convenient mathematical fiction. The surface layer is indicated by doubling the dashed line representing the inner level surface. The isostatic reduction would give nearly the same result.

Again suppose the level surface to be a sphere in spite of the axial rotation. (See lower right-hand corner of Fig. 2.) In the formula of Clairaut's theorem

$$\frac{g_p - g_e}{g_e} = \frac{5}{2}m - f$$

put $f=0$. Then the difference between equatorial and polar gravity is as large as possible—short of making f negative, that is, making the level surface prolate. But if we are absolutely determined that the sphere shall be a level surface in spite of the rotation, we must provide a suitable distribution of matter within it regardless of internal stresses. Such a distribution is suggested by the doubly cross-hatched portions of the diagram, intended to suggest the presence of matter of high density and the single hatched portions, intended to suggest matter of low density. This extra density near the poles and the deficient density near the equator account for the great difference in gravity between pole and equator, although the flattening is zero.

These two examples are merely an attempt to make Clairaut's theorem seem less of a paradox. Of course, they are not a proof.

It is quite clear that Clairaut made no assumption as to hydrostatic equilibrium or the lack of it within the spheroid to which his theorem applies. Nevertheless in later years the impression became widespread that he assumed internal fluidity. The agreement of the ellipticities deduced from pendulum experiments and Clairaut's theorem with those deduced from arc measurements was often cited as an argument in favor of internal fluidity. Stokes in giving a proof of Clairaut's theorem remarks that the theorem has been connected with the assumption of fluidity but that his (Stokes') proof does not require it. He adds that Laplace had proved a theorem analogous to

Clairaut's without assuming fluidity but says nothing of what Clairaut himself had proved.

This misconception may have arisen because Clairaut did prove another interesting theorem that does imply internal fluidity. It is a differential equation; for the geodesist it is *Clairaut's differential equation.* Needless to say it is not the Clairaut's differential equation of the mathematician, namely:

$$y=p\,x+f(p),$$

where $p=\frac{dy}{dx}$. To the geodesist Clairaut's differential equation is

$$\frac{d^2\epsilon}{dr^2}+\frac{2\rho r^2}{M}\frac{d\epsilon}{dr}+2\left(\frac{\rho r}{M}-\frac{6}{r^2}\right)\epsilon=0,$$

where $M=\int_c^r \rho\, x^2\, dx$. I shall not explain the notation nor discuss the equation in detail, nor mention some interesting modern developments in connection with it. It connects the ellipticities of the level surfaces within the earth with their radii and with the assumed law of density—on the hypothesis of hydrostatic equilibrium. With any physically probable law of density within the earth, the ellipticities of the level surface within the earth decrease toward the center.

STOKES

The theoretical basis for the study of the figure of the earth in detail by means of gravity methods was laid by George Gabriel Stokes, born in 1819. Stokes was the eldest of a famous trio of mathematical physicists; the others were James Clark Maxwell and William Thomson (Lord Kelvin).

Fig. 1 shows Stokes as an elderly man, almost seventy years of age.[13] He was only thirty when he made his great contribution to the study of the figure of the earth in detail, the "humps and hollows of the geoid," as we sometimes say with more picturesqueness than literal accuracy, for the word "hollows" suggests negative curvature, and this condition is rare or non-existent; the geoid for all practical purposes is everywhere convex.[14]

If we take a closed surface enclosing all attracting matter and assert that it is a level surface for that attracting matter, and if we

[13] From the *Illustrated London News* of 1887.

[14] A case of possible negative curvature of a level surface has been found in the Simplon tunnel by observations with the Eötvös torsion balance.

assign a value of gravity at any point on or outside the surface, then we can determine from the form of the level surface itself the value of gravity everywhere outside of it. The analytical and numerical work may be difficult or, for all practical purposes, impossible, but theoretically the thing is possible. Uniform rotation about a fixed axis adds but little to the difficulty. The international formula for gravity is based on the assumption that the surface of reference, which is at the same time a level surface, is an absolutely exact ellipsoid of revolution with a pre-assigned flattening, 1/297.

How about a sort of inverse problem? Given gravity on what we know to be a level surface enclosing all attracting matter, can we determine the form of the surface? If we have a fair previous idea of the form of the surface, the answer is: "yes, for all practical purposes." Stokes showed how it could be done in the case of the geoid, for which we have, as a fair approximation, a sphere or an ellipsoid.

We must in theory know gravity all over the geoid. When Stokes wrote his memoir *On the variation of gravity on the surface of the earth*[15] this must have seemed an assumption to be made chiefly for its speculative interest. Today we are still far from realizing this ideal, but with the method and apparatus of Vening Meinesz for determining gravity at sea, the possibility of realizing it exists, though it is premature to say that the realization is in sight.

Stokes dealt with gravity anomalies, the differences between observed gravity reduced to the geoid, g_0, and theoretical gravity according to some formula, γ_0, the formula implying a level surface, which is also a spheroid of reference. In $\Delta g = g_0 - \gamma_0$, g_0 and γ_0 refer to two different surfaces. Stokes saw this and allowed for the fact in his formulas. The same point comes up later in connection with Special Publication No. 199 of the Coast and Geodetic Survey. Suppose Δg expressed as a series of spherical harmonic terms

$$\Delta_g = G\ (u_2 + u_3 + u_4 + u_5 \cdots).$$

The u's are general surface spherical harmonics, functions of the latitude and longitude. G is a mean value of gravity over the earth. The degrees of the harmonic terms are indicated by the subscripts. The terms of degree zero can be made to disappear by choosing a proper mean value of gravity. Even if a term of degree zero were included, it would have no effect on the final result. The term of the first degree simply must not appear; if it does appear, there has been a mistake

[15] Transactions of the Cambridge Philosophical Society, **8**: 672, or Mathematical and Physical Papers, **2**: 131.

somewhere, and even if it did appear, the final result would be unchanged.

Then, says Stokes, it follows from this that if we call N the distance between the geoid and the spheroid of reference implied by the formula for theoretical gravity, then N is given by

$$N = a\left(\frac{u_2}{1} + \frac{u_3}{2} + \frac{u_4}{3} + \frac{u_5}{4} \cdots + \frac{u_n}{n-1} \cdots\right),$$

a being the radius of the sphere or the mean radius of the ellipsoid.

The quantity N, positive or negative as the case may be, gives us the "humps and hollows" of our geoid referred to the spheroid implied by the formula for γ_0.

It is easy to say that u_n represents a surface spherical harmonic of degree n, but when we remember that it is composed of $2n+1$ tesseral and zonal harmonics, each with a coefficient to be determined, we see that the work of determining even a few terms of the expansion is formidable. And when we reflect on the capricious variability of gravity anomalies, it becomes evident that the number of terms needed for even a very generalized expression of Δg would be overwhelming and the rapid convergence of the expression, supposing such an expression found, very much in doubt.

Stokes did not have in 1849 anything like the number of gravity anomalies that we now have, but he realized that his expansions in spherical harmonics would be practically unworkable for most purposes, that they could be merely stages on the way to something better. He does a few tricks with the series for N—Laplace had already done something of the sort—and transforms it into a surface integral

$$N = \frac{a}{4\pi G}\int \Delta g f(\psi)\, d\omega,$$

where $f(\psi) = 1 + \operatorname{cosec} \frac{1}{2}\psi - 6 \sin\frac{1}{2}\psi - 5 \cos\psi - 3 \cos\psi \log_e(\sin\frac{1}{2}\psi + \sin^2\frac{1}{2}\psi)$. This means in practice that we take a point, say A, for which N is desired, call ψ the angular distance on the earth from this point to some other point B, multiply $f(\psi)$ by the value of Δg for the element of solid angle ω for the portion of the earth surrounding B and that we thus evaluate our integral numerically by taking elements of solid angle and their corresponding anomalies over the entire earth. The terms in the expression for $f(\psi)$ have no individual physical meaning. They are simply the results of mathematical manipulation.

Stokes did not forget the possibility that the series from which was derived the integral that he proposed for actual calculation might not be convergent but he made no elaborate investigation. The validity of the transformation from series to integral was studied by others and finally in 1911 Pizetti[16] gave a proof that dispensed with the series altogether and derived the final result from Green's theorem. Poincaré had previously done about the same thing; it seems to have been an independent rediscovery of Stokes' formula, for Poincaré makes no mention of Stokes. (See article entitled *Les mesures de gravité et la géodésie*, Bulletin Astronomique. **18**: 7. 1901.) Pizetti also showed for the case of a spheroidal earth that the approximation is better than Stokes or Helmert felt justified in asserting it to be. In fact, it is amply good for present purposes.

Lately with the increasing possibility of the application of Stokes' theorem[17] to the practical problem of geodesy there has been an increasing interest in it and various proofs along the same general lines as that of Pizetti have recently been published. The theory of integral equations has also been brought into the discussion. Because these proofs dodge the thorny question of convergence they are preferable to Stokes' original proof but his arguments from spherical harmonics has the advantage of bringing out, as the other methods of proof do not, the relative importance of local and regional effects on the two elements that contribute to the gravity anomalies, namely: (1) the direct effect on gravity of the irregular distribution of matter; (2) the indirect effect due to this warping, because the observed values of gravity are reduced to the geoid, not to the spheroid of reference. They cannot be reduced to the latter because, until we have used Stokes' formula, we do not know where the spheroid is by tying it to anything observable.

[16] P. Pizetti. *Sopra it calcolo teorico delle deviazione del geoide dell' ellissoide.* Atti delle Reale Accademia delle Scienze di Torino, **46**: 331, 1911. See also the following still more recent discussions among others: C. Mineo. *Sulla forma della terra.* Rendiconti del Circolo matematico di Palermo **51**: 1, 1927. N. Idelson and N. Malkin, *Die Stokessche Formel in der Geodäsie als Randwertaufgabe,* Gerlands Beiträge zur Geophysik, **29**: 156, 1931. Also N. Malkin, *Über die Bestimmung der Figur der Erde.* Gerlands Beiträge zur Geophysik, **45**: 133. 1935. J. de Graaff Hunter, *The figure of the earth from gravity observations and the precision obtainable,* Philosophical Transactions of the Royal Society of London. **234**: Ser. A: 377. 1935.

[17] Stokes' theorem means to the geodesist what has just been described. As was the case with Clairaut, the discoverer's name has been also specially attached to another important theorem. To the mathematical physicist Stokes' theorem means that: The line integral taken around a closed curve s, of the tangential component of an analytic vector point function Q, is equal to the surface integral taken over any surface S, bounded by the curve, of the normal component of the curl of the vector, the direction of integration around the curve forming a right-handed screw rotation about the normals.

Stokes' theorem is the only means we have of studying the "humps and hollows" of the geoid at sea. On land we have other methods, and in certain respects more accurate ones. These are the deflections of the vertical, the differences between astronomical latitudes, longitudes and azimuths and the corresponding geodetic quantities. From these deflections, if they are closely enough spaced, we can build up the elevations of the geoid above our spheroid of reference. But the spheroids of reference in regions sundered by the intervening seas are in no ascertainable relation to one another, even though the assumed dimensions of these spheroids may be the same. Even though two originally separated pieces of triangulation may later be united and referred to a spheroid of the same dimensions and having the same position and orientation, there is no assurance that the center of this spheroid coincides with the center of gravity of the earth. But Stokes' formula automatically places the center of our spheroid of reference at the center of gravity of the earth. It will not give elevations and depressions of the geoid referred to a spheroid with any other center.

It is to be hoped, therefore, more observations of gravity will be made in the open sea in the near future. The sea covers nearly three-fourths of the surface of the earth and we cannot get a valid idea of the figure of the earth, even as a whole, much less in detail, nor of the structure of the crust until we have many more gravity observations at sea.

COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO. 199

We have passed in brief review the contributions of these leaders of thought to the problem of determining the figure of the earth from gravity observations. In closing let me refer briefly to a small contribution to the practical side of the problem, namely the computation of certain tables appearing in Special Publication No. 199 of the Coast and Geodetic Survey. Incidentally this publication contains more complete tables of Stokes' functions than have hitherto been published; these are in great part an extension of tables computed by Schumann.[18]

But the table of Stokes' functions was not the primary purpose of the publication. Its purpose is to provide means of estimating the indirect effect on gravity of irregular distribution of mass, such as we

[18] R. SCHUMANN, *Geoidabstände nach der Formel von Stokes bei schematischen Schwerebelegungen,* Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien. Mathem.-naturw. Kl., **120**: Abt. IIA: 1655. 1911.

see in the relief of the earth's surface, and which we assume to be correlated with them when we adopt the assumption of isostatic compensation. The direct effect of such masses, their vertical attraction at a given point, was already taken care of by existing tables. But there is an indirect effect. It has been known since the time of Stokes that part of the gravity anomaly is due to the fact that observations are reduced to the geoid, not to the spheroid of reference. The same problem comes up in slightly different guise in connection with the isostatic reduction of gravity. When we move matter around, as we do in imagination in making an isostatic reduction, we change the form of the level surfaces. As a result of the hypothetical transfer of matter implied by the theory of isostasy, the actual geoid becomes what the Survey of India calls the "compensated geoid." If the assumed theory of isostasy were correct to the last detail, the compensated geoid would be the spheroid of reference. Isostatic reductions hitherto made have been incomplete, in that no allowance was made for the difference between the actual geoid and the compensated geoid, or spheroid.

The warping H, of the geoid due to any addition, subtraction or transfer of matter, isostatic or non-isostatic, may be put in the form

$$H = \frac{V}{g},$$

where V is the potential of the addition, subtraction or transfer and g is the acceleration of gravity. Certain precautions may be needed in using this equation but, even so, it is clear that what was needed was a table of potentials of certain masses or of quantities proportional to the potentials.

The obvious choice for the horizontal boundaries of these masses was the set of Hayford zones already used for isostatic reductions and recommended by the International Association of Geodesy for international adoption. As a step towards the isostatic tables, tables were computed adaptable to any distribution (within the limits set by the Hayford zones and reasonable ranges of thickness) whether isostatic or not. The tables and the explanation of how they were computed and how to use them, constitute Special Publication No. 199 of the Coast and Geodetic Survey.

CRYSTALLOGRAPHY.—*The crystal structure of krennerite.*[1]
GEORGE TUNELL and C. J. KSANDA, Geophysical Laboratory, Carnegie Institution of Washington.

The rare telluride of gold and silver, krennerite, has been the subject of several morphological investigations. Faceted crystals of krennerite have been measured with the reflection goniometer by J. A. Krenner,[2] G. vom Rath,[3] A. Schrauf,[4] H. A. Miers,[5] and G. F. Herbert Smith.[6] They found the symmetry of the crystals to be that of the orthorhombic system. The values of the axial elements calculated by the various authors are given in Table 1.

TABLE 1.—AXIAL ELEMENTS OF KRENNERITE.

	a	*b*	*c*
VOM RATH	0.9407	1	0.5045
SCHRAUF	0.9396	1	0.5073
MIERS	0.9389	1	0.5059
SMITH	0.9369	1	0.5068

The investigations of calaverite by S. L. Penfield and W. E. Ford,[7] G. F. Herbert Smith,[8] and V. Goldschmidt, C. Palache, and M. Peacock[9] proved that krennerite and calaverite are quite different morphologically. The present writers have now established essential differences in crystal structure by the study of faceted crystals of krennerite and calaverite with the Weissenberg X-ray goniometer, the two-circle reflection goniometer, and the reflecting microscope.[10] Thus the statement of J. Murdoch[11] that "Krennerite is the same as calaverite" has been proved erroneous. Recently Borchert[12] concluded from studies of polished surfaces of calaverite and krennerite with the reflecting microscope, that calaverite is the high temperature modification and krennerite the low temperature modification of the same compound. He regards the faceted, apparently single, crystals

[1] Received October 30, 1936.
[2] J. A. KRENNER, Ann. f. Phys. und Chem., **1**: 636–640. 1877.
[3] G. VOM RATH, Zeit. f. Kryst. und Min., **1**: 614–617. 1877.
[4] A. SCHRAUF, Zeit. f. Kryst. und Min., **2**: 235–239. 1878.
[5] H. A. MIERS, Min. Mag., **9**: 184–186. 1890.
[6] G. F. HERBERT SMITH, Min. Mag., **13**: 264–267. 1903.
[7] S. L. PENFIELD and W. E. FORD, Amer. Jour. Sci., (4) **12**: 225–246. 1901.
[8] G. F. HERBERT SMITH, Min. Mag., **13**: 122–150. 1902.
[9] V. GOLDSCHMIDT, C. PALACHE, and M. PEACOCK, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **63**, Abt. A: 1–58. 1932.
[10] The authors are greatly indebted to Prof. L. C. Graton and Dr. E. B. Dane, Jr., of Harvard University for their kind assistance in the preparation and examination of the polished surfaces of krennerite and calaverite, and for the use of their polishing equipment and reflecting microscope.
[11] J. MURDOCH, Microscopical determination of the opaque minerals, p. 124, 1916.
[12] H. BORCHERT, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **61**, Abt. A: 106-116. 1930; also Beilage-Band **69**, Abt. A: 466–472. 1935.

of calaverite as paramorphs having the internal structure of krennerite (Borchert refers to the faceted, apparently single, crystals of calaverite as "Original-α-Calaverit" and to krennerite as "primärer β-Calaverit"). However, we have found that in each of these two minerals the structural axes (determined röntgenographically) and morphological axes (deduced from the study of the external form) exhibit such close correspondence that it is impossible to suppose that either one has passed through a polymorphic inversion. We[13] have proved elsewhere that the structural axes of calaverite coincide with its morphological *S*-axes in direction, and that the values of the axial elements determined röntgenographically by us agree very closely with the values of the morphological *S*-elements determined by Penfield and Ford, G. F. Herbert Smith, and Goldschmidt, Palache, and Peacock. In the present investigation we have found that the structural axes of krennerite coincide with its morphological axes in direction, and that the axial elements calculated from the dimensions of the structural unit cell, namely, $a:b:c=1.876:1:0.506$, agree well with the morphological axial elements if the value of a in the morphological elements be multiplied by 2.

Well developed faceted crystals of krennerite[14] from Cripple Creek, Colorado, previously measured by Dr. M. A. Peacock on the two-circle reflection goniometer, were used in our röntgenographic investigation. The dimensions of the structural unit cell were determined from Weissenberg photographs taken by means of Cu-radiation with the crystal rotating around the a-, b-, and c-axes (orientation of vom Rath), and found to be: $a_0=16.51$Å, $b_0=8.80$ Å, $c_0=4.45$ Å, all ± 0.03 Å. The unit cell contains 8 *molecules* of $AuTe_2$. An analysis by W. S. Myers[15] of faceted crystals of krennerite from Cripple Creek showed that a very small proportion of the gold is replaced by silver, which appears to be held in solid solution. The systematically missing spectra limit the space-groups possible for krennerite to three, namely, $Pmc-C_{2v}^2$, $Pma-C_{2v}^4$, and $Pmma-V_h^5$. From an analysis of the intensities of the diffraction spots on our Weissenberg negatives, from consideration of the close relationship between the structural lattices of krennerite and calaverite as determined by the Weissenberg study of single crystals, and from the close similarity of the powder photographs of the two minerals both as to positions and intensities of the diffraction lines, the atomic arrangement in krennerite must be one

13 Tunell and Ksanda, this Journal **26**: 509–528. 1936.

14 Kindly supplied by Prof. Charles Palache and Dr. M. A. Peacock of Harvard University, to whom the authors wish to express their appreciation.

15 Amer. Jour. Sci., (4) **5**: 376. 1898.

TABLE 2.—ARRANGEMENT OF THE 8 GOLD AND 16 TELLURIUM ATOMS IN THE UNIT CELL OF KRENNERITE.

Kind of Atom	Set of Equivalent Positions	Number of Equivalent Positions in Set	x	y	z
Au	(a)	2	0	0	0
Au	(c)	2	0.25	0.32	0.01
Au	(d)	4	0.12	0.67	0.50
Te	(c)	2	0.25	0.03	0.04
Te	(c)	2	0.25	0.63	0.04
Te	(d)	4	0.00	0.30	0.04
Te	(d)	4	0.13	0.37	0.50
Te	(d)	4	0.12	0.97	0.50

that is isomorphous with the space-group $Pma - C_{2v}^4$. The values of the 18 parameters were determined from the intensities[16] alone and are given in Table 2. The intensity calculations on which the determination of the atomic arrangement in krennerite rests, and the relationship between the crystal structures of krennerite and calaverite will be discussed in greater detail in a subsequent communication.

CRYSTALLOGRAPHY.—*The strange morphology of calaverite in relation to its internal properties.*[1] GEORGE TUNELL and C. J. KSANDA, Geophysical Laboratory, Carnegie Institution of Washington.

THE MORPHOLOGICAL PROBLEM OF CALAVERITE

The tiny, metallic, pale-yellowish crystals of calaverite are bounded by a strange array of faces, which has remained an enigma to crystallographers for more than 30 years. Exhaustive studies by several competent observers[2] established the angular relations of the faces of calaverite crystals, but it was found impossible to reconcile these relations with the law of simple rational indices as applied to a single crystal. This failure has led some investigators to question the general validity of the law of simple rational indices;[3] it has caused others[4]

[16] The authors are much indebted to Mrs. Ruth Philips Tunell for assistance in the calculation of the intensities.

[1] Received October 22, 1936.

[2] See V. GOLDSCHMIDT, C. PALACHE and M. PEACOCK, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **63**, Abt. A: 50–52. 1932, for a careful account of the history of the investigation of calaverite; valuable data in this connection are also given by M. A. PEACOCK, American Mineralogist **17**: 318. 1932.

[3] V. GOLDSCHMIDT, C. PALACHE and M. PEACOCK, op. cit., pp. 56–57, M. A. PEACOCK, op. cit., pp. 317–318.

[4] G. F. HERBERT SMITH, Mineralogical Magazine, **13**: 122–150. 1902. H. BORCHERT, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **61**, Abt. A: 106–116. 1930; also Beilage-Band **69**, Abt. A: 466–472. 1935. J. D. H. DONNAY, Annales de la Société géologique de Belgique, **58**: B222–230. 1935.

to attempt to interpret even those crystals of calaverite which appear to be simple, untwinned, individuals as some unfamiliar type of crystal intergrowth (ordinary types of twinning having been excluded for these apparently single crystals).

THE SYMMETRY OF CALAVERITE

In studying a number of excellent calaverite crystals[5] from Cripple Creek, Colorado, with the Weissenberg X-ray goniometer, as well as with the two-circle reflection goniometer and the reflecting microscope, we have obtained data that throw some new light on the problem of the morphology of calaverite. We[6] had previously proved that of the two alternatives for the symmetry of calaverite not excluded with certainty by Goldschmidt, Palache, and Peacock,[7] namely, orthorhombic and monoclinic, the first is incompatible with the observed intensities of the X-ray diffraction spots on our Weissenberg negatives. The planes, hkl and $hk\bar{l}$, in general yield diffraction spots of very different intensity on these negatives. This would not be possible if calaverite belonged to the othorhombic system, irrespective of the space-group in the orthorhombic system with which it might be isomorphous. It is therefore certain that calaverite does not belong to the orthorhombic system.

THE STRUCTURAL LATTICE AND ITS CORRELATION WITH THE MORPHOLOGICAL *S*-LATTICE

The reciprocal lattice of calaverite was established by us by means of Weissenberg photographs taken with Cr-, Cu-, and Mo-radiation. The structural lattice has elements strictly analogous to the fundamental morphological elements of G. P. & P. (their *S*-elements). In our previous communication we[8] gave preliminary values of the unit cell dimensions, determined by purely röntgenographic measurements, as follows: $a_0 = 7.18$ Å, $b_0 = 4.40$ Å, $c_0 = 5.07$ Å, all ± 0.03 Å, $\beta = 90°$ $\pm 30'$. We stated further that the correspondence between the positive and negative senses of our axes and those of G. P. & P. had not been established at that time but only the correspondence between the directions of our axes and the *S*-axes of G. P. & P. Subsequently we have been able to prove by the following methods that the positive senses of our three axes correspond to the positive senses of the

[5] Kindly furnished for the purpose by Dr. W. F. Foshag of the United States National Museum, to whom the authors' thanks are due.

[6] G. Tunell and C. J. Ksanda, this Journal, 25: 32–33. 1935.

[7] In the remainder of this paper in references to the joint work of Goldschmidt, Palache, and Peacock, the initials G. P. & P. are used for the sake of brevity.

[8] Tunell and Ksanda, op. cit., p. 33.

three *S*-axes of G. P. & P. The faces of a small, well faceted crystal were identified by measurement on the two-circle reflection goniometer. Unlike many calaverite crystals this one gave quite satisfactory reflections in the prismatic[9] zone.[10] Eight forms were present in this zone of which seven were identified with the following forms of G. P. & P.: *E*, Λ:, *a*, *c*, *A*, ω:, *K*:. The two most prominent forms and those yielding the best signals were *E* and Λ:. The crystal was then mounted on the Weissenberg X-ray goniometer with the prismatic zone adjusted parallel to the rotation axis. The crystal was rotated about the axis of the prismatic zone until an easily recognizable plane, the ϕ and ρ angles of which were determined on the two-circle reflection goniometer, was brought into a position perpendicular to the X-ray beam. The establishment of the position of this plane in which it was perpendicular to the X-ray beam was accomplished by means of an auxiliary reflection goniometer, which can be attached to our Weissenberg X-ray goniometer in a precise manner such that the axis of the auxiliary goniometer is at right angles to the rotation axis of the Weissenberg X-ray goniometer carrying the crystal, and coincides with the center line of the X-ray beam (the Weissenberg X-ray goniometer being set so that the rotation axis carrying the crystal is perpendicular to the X-ray beam).[11] With the rotation axis of the Weissenberg goniometer (carrying the crystal) set and clamped so that the recognized plane of the crystal was perpendicular to the X-ray beam, the film-carriage was coupled to the rotation axis, and a spot was made on the film with a two or three second exposure of the direct beam. Given the zone of the crystal that is parallel with the rotation axis of the Weissenberg goniometer, and given the end of the crystal by which it is attached, there are of course two positions of the crystal in which the recognizable plane lying in the zone paral-

[9] The zone parallel to the *b*-axis (*S*-elements) of calaverite is prismatically dedeveloped and is referred to by G. P. & P. as the prismatic zone. Thus they state that "Die Zone prismatischer Entwicklung des Calaverit ist also die Querdomenzone. Aber wir können diese Zone kurz 'prismatische Zone' nennen, da sie prismatischen Charakter hat, obwohl sie nicht die Prismenzone ist." Op. cit., p. 8.

[10] This crystal was found in the interior of a larger, hollow calaverite crystal. This protected situation may have contributed to the perfection of growth and the excellent preservation of the small crystal.

[11] This X-ray goniometer was constructed in the Fysisk Institutt of Norges Tekniske Høiskole at Trondheim, Norway (cf. H. BRÆKKEN, Zeit. f. Krist., **81**: 309–313. 1932, for a description of this instrument with photographs), and was modified by us so as to render it more readily available for the application of the equi-inclination technique, in accordance with the scheme of M. J. BUERGER (Zeit. f. Krist., **88**: 358–359. 1934). The adjustments necessary with this modified apparatus were carried out by us by means of auxiliary apparatus constructed for the purpose in the shop of the Geophysical Laboratory. The source of radiation used in conjunction with this X-ray goniometer is a gas tube described by C. J. KSANDA (Rev. Sci. Instr., **3**: 531–534. 1936).

lel with the rotation axis is perpendicular to the X-ray beam; at the time the direct beam spot was made a note was written down as to which of these two positions the crystal occupied. A shield was then inserted to prevent the direct beam from impinging on the film (the coupling of the film-carriage and rotation axis not being disturbed), the layer-line screen was inserted, and an equator Weissenberg photograph was made. When the film was removed from the film-carriage, a small scratch mark was made on the film in a particular corner and on the side of the film that was nearest the crystal; by means of this scratch mark the film could, in theory, be replaced on the film-carriage after development in the same position that it occupied during the exposure. Then, since the position of the film and carriage when the recognizable plane of the crystal was perpendicular to the X-ray beam was such that the direct beam spot on the film was precisely in front of the pin-hole, and since the sense of the translation of the film-carriage corresponding to a given character of rotation of the crystal (clockwise or counter-clockwise, the observer looking at the free, unattached end of the crystal) is always known from the construction of the instrument, therefore the position of the crystal, and in particular the position of each of its external faces (the symbols of which according to the indexing of G. P. & P. had been previously determined by measurements on the Goldschmidt two-circle reflection goniometer) when each diffraction spot was being formed on the Weissenberg negative, was uniquely and rigorously determined with respect to the rotation axis of the Weissenberg goniometer and the X-ray beam.[12] Thus the Miller indices corresponding to the *S*-axes of G. P. & P. of the plane producing each diffraction spot on the film were uniquely determined, and were found to be the same both numerically and in respect to all their positive and negative signs as those previously assumed provisionally by us[13] (before we found which of the angles between the *a*- and *c*-axes was greater than 90°).

In the foregoing discussion the correlation of the senses of our three axes with the senses of the three *S*-axes of G. P. & P. was rigorously established. Moreover this correlation did not depend in any way on

[12] The precise correlation of the external faces of a crystal with its structural (diffraction) planes is carried out by us as a routine by the above method, which, although its expression in words is cumbersome, is really simple and convenient in practice, and automatically prevents some possible confusions that might otherwise occur in structural work.

[13] In our preliminary report on the crystal structure of calaverite (this JOURNAL, **25**: 32–33. 1935) we merely stated that $\beta = 90° \pm 30'$ and assumed positive senses of all our structural axes without reference to the morphology of the crystals. This did not affect the determination of the crystal structure but merely left to the future the determination of the relation between the positive and negative senses of our structural axes and the positive and negative senses of the *S*-axes of G. P. & P.

the recognition of the obtuse and acute angles between the normals to the forms *a* and *c*, either by G. P. & P. or by us, but on the contrary rested on the identification of the characteristic forms *E*, Λ:, *A*, ω:, *K*:. The designation of *A* and *E* as positive *S*-forms by G. P. & P. of course depended on their measurements of the angle between the normals to the forms *a* and *c;* the average of their measurements of this angle was reported to be 89°54′; the value calculated by G. P. & P. is 89°52′.[14] Concerning the angle between the normals to the forms *a* and *c* they[15] wrote: "Dieser Winkel ist so nahe an 90°, dass die Frage, ob der Neigungswinkel von 90° verschieden ist, nicht aus den Messungen entschieden werden kann." The angle between the normals to the forms *a* and *c* determined previously by Penfield and Ford[16] was 89°47⅓′ and that determined by G. F. Herbert Smith[17] was 89°50′. The same forms were found to lie with their normals in the acute angle between the normals to the forms *a* and *c* in all these investigations. With the reflection goniometer we had measured the angle between the normals to the forms *a* and *c* of the crystal mentioned in the preceding paragraph to be 89°56′, and we had found the same forms to lie with their normals in the acute angle between the normals to the forms *a* and *c* as G. P. & P. Although any single measurement of the angle between the normals to the forms *a* and *c* with the reflection goniometer might be in error by an amount as great as the difference from 90° of the angle between the normals to the forms *a* and *c*, it is extremely improbable that previous investigators would all have obtained a value greater than 90° for the angle that is really less than 90°, and all have reached a wrong conclusion as to which forms are positive and which are negative. Moreover in our later studies with the Weissenberg goniometer on the same crystal we were able to prove by röntgenographic measurements alone that the angle between the normals to the planes 100 and 001 differs from 90° a little more than the probable experimental error—from our röntgenographic measurements this angle equals 89°47′—and the external faces found to lie with their normals in the acute angle between the normals to 100 and 001 determined röntgenographically were the same ones found to lie with their normals in the acute angle between the normals to 100 and 001 determined with the reflection goniometer. Thus our röntgenographic studies afford a definite confirmation of the conclusion of Penfield and Ford, G. F. Herbert Smith, and G. P. & P.,

[14] G. P. & P., op. cit., p. 29.
[15] G. P. & P., op. cit., p. 5.
[16] S. L. Penfield and W. E. Ford, Amer. Jour. Sci., (4) **12**: 227. 1901.
[17] Op. cit., p. 135.

based on studies with the reflection goniometer, as to which of the forms are positive and which are negative.

Since the axial elements computed from the unit cell dimensions determined by purely röntgenographic measurements agree with those previously determined by Penfield and Ford,[18] G. F. Herbert Smith,[19] and G. P. & P.[20] very closely, it might be assumed without further investigation that no polymorphic inversion has taken place in the calaverite crystals and that the structural planes lie parallel with the analogous crystal faces. However, in view of the various hypotheses that have been suggested by different authors to account for some of the peculiarities of calaverite, and in view of the fact that its morphological development appears to violate the fundamental crystallographic law of simple, rational indices, it is desirable to establish the relationship between the crystal faces and structural planes as fully and exactly as possible by measurement and observation alone. The procedure described above for the correlation of the external faces of a crystal with its structural (diffraction) planes by means of a spot on the Weissenberg negative produced by a short exposure of the direct X-ray beam when the faces of the crystal occupied a defined position with respect to the rotation axis of the Weissenberg goniometer and the X-ray beam, permitted us to prove that the S-axes defined by the morphology of the crystal are parallel with the structural axes of the same crystal (within the limits of error of our measurement of the angle between an external face and a structural plane, which are $\pm 1°$).[21]

[18] Op. cit., p. 227. [19] Op. cit., p. 135.

[20] G. P. & P., op. cit., p. 6. M. A. Peacock, op. cit., p. 325.

[21] Little need has previously arisen for a measurement of the angle between an external face of a crystal and a structural (diffraction) plane of the same crystal, and it is probably desirable that we explain just what is meant by such a measurement. By the angle between an external crystal face and a structural (diffraction) plane of the same crystal we mean the angle through which the crystal was turned from the position in which the external face occupied an arbitrary position with respect to the rotation axis of the Weissenberg goniometer and the X-ray beam, as determined by means of the auxiliary reflection goniometer, until the structural (diffraction) plane occupied the same arbitrary position, as determined by the positions of the diffraction spots from the structural plane in relation to the shadow of the crystal in the central portion of the spot made by a short exposure of the direct X-ray beam when the external crystal face occupied the arbitrary position at the beginning of the measurement. The determination of the angle between the normals to the planes 100 and 001 by purely röntgenographic measurements was more accurate than such a measurement of the angle between an external face of the crystal and a structural (diffraction) plane, as the former is not subject to certain factors of error that affect the latter: the former depends merely on the relative positions of the diffraction spots of the two structural planes 100 and 001 on a single Weissenberg negative, whereas the latter depends on the relative positions of the diffraction spots from one structural plane with respect to the shadow of the crystal in the central portion of the spot made by the short exposure of the direct X-ray beam when the external face of the crystal occupied a defined position with respect to the rotation axis of the Weissenberg goniometer and the X-ray beam.

THE CRYSTAL STRUCTURE OF CALAVERITE

The crystal structure of calaverite has already been described by us[22] in a preliminary communication. The arrangement of the two gold and the four tellurium atoms in the unit cell is rather simple; it can be realized in either the space-group $C2/m - C_{2h}^3$, or the space-group $C2 - C_2^3$, and the parameters have been evaluated on the basis of both alternatives and found to be the same. Besides the gold and tellurium required by the formula $AuTe_2$, calaverite contains a small amount of silver, ranging, in the analyses of crystallographically studied material, from 0.40 to 3.23 per cent.[23] This silver appears to be held in solid solution, but the exact mode of disposition of the silver atoms in the structure requires further study in the search for a more complete explanation of the relation between the structure and morphology of calaverite.

PREVIOUS MORPHOLOGICAL INVESTIGATIONS OF CALAVERITE AND THE PECULIARITIES IN MORPHOLOGY THEREBY FOUND TO BE CHARACTERISTIC OF CALAVERITE CRYSTALS

In their investigation, which first established the symmetry and axial elements of calaverite, Penfield and Ford[24] noted that the angles between certain faces of calaverite agreed very closely with the angles between corresponding faces of sylvanite. This relation is shown by Table 1 from Penfield and Ford.[25,26]

Table 1.—A Comparison of Calaverite and Sylvanite from Penfield and Ford.

Calaverite	Sylvanite
$m \wedge m'$, $110 \wedge \bar{1}10 = 63° \ 1'$*	$110 \wedge \bar{1}10 = 62°56'$
$p \wedge p$ $111 \wedge \bar{1}1\bar{1} = 93 \ 49$	$111 \wedge \bar{1}1\bar{1} = 94 \ 30$
$m \wedge p$ $110 \wedge 111 = 36 \ 38$*	$110 \wedge 111 = 37 \ 3$
$m' \wedge p$ $\bar{1}10 \wedge 111 = 68 \ 45$*	

From the measurements marked by asterisks Penfield and Ford calculated the values of Table 2 for the axial elements of calaverite, which they compared with the axial elements of sylvanite determined by Schrauf.[27]

[22] Tunell and Ksanda, op. cit., p. 33.
[23] Penfield and Ford, op. cit., p. 246. G. F. Herbert Smith, op. cit., p. 149.
[24] Op. cit., p. 227.
[25] Op. cit., p. 227.
[26] The faces designated *m* and *p* by Penfield and Ford were designated with the same letters by G. P. & P.
[27] A. Schrauf, Zeit. f. Kryst. u. Min., **2**: 211. 1878.

TABLE 2.—COMPARISON OF AXIAL ELEMENTS OF CALAVERITE AND SYLVANITE.

	a	b	c	β
Calaverite (Penfield and Ford)	1.6313	1	1.1449	$90°12\frac{2}{3}'$
Sylvanite (Schrauf)	1.6339	1	1.1265	$90°25'$

The close similarity of the two sets of elements was considered by Penfield and Ford as evidence in favor of their choice of the elements of calaverite.

G. P. & P.[28] later selected polar elements analogous to the linear elements of Penfield and Ford as the fundamental polar elements of calaverite. These polar elements, namely, $p_0:q_0:r_0=0.7051:1.1492:1$, $\mu=89°52'$, G. P. & P. designate as the polar S-elements. With respect to the S-elements, the three established twinning laws of calaverite are as follows. "1. The twinning and composition plane is $V(101)$; the axes of the prismatically developed zones of the two individuals are parallel. 2. The twinning and composition plane is $\beta(310)$; the axes of the prismatically developed zones of the two individuals intersect at 122°58′. 3. The twinning and composition plane is $p(111)$; the axes of the prismatically developed zones of the two individuals intersect at 93°40′."[29] Concerning these twinning laws G. P. & P.[30] conclude that: "Die Zwillingsebenen des Calaverit sind alle einfache S-Flächen. Dies spricht für die grundlegende Wichtigkeit dieser Elemente. Das gemeinste Gesetz des Calaverit, $V=\infty\,(110)\,S(M_2)=10(101)S(M_1)$,[31] ist auch das Hauptzwillingsgesetz des Sylvanit [Zwillingsebene $m=10(101)M_1$]." Furthermore Donnay[32] has shown that these three twinning laws are readily explained by the Bravais-Mallard-Friedel theory of twinning if the S-lattice is taken as the morphological lattice of calaverite. The index and the obliquity of each of these three kinds of twins are small and the relative values of these quantities lead to an expectation concerning the frequency of occurrence which is in agreement with the data of observation—"macle $V(101)$, indice 3, obliquité 0°25′; la plus probable; macle

[28] Op. cit., p. 6.
[29] M. A. Peacock, op. cit., p. 325.
[30] Op. cit., p. 20.
[31] The symbol $\infty\,(110)S(M_2)$ of the face V here indicates that when the crystal is projected on a plane perpendicular to the symmetry axis (b-axis), the Goldschmidt symbol of the face V is ∞ referred to the S-axes in this orientation (the M_2-orientation); the Miller indices (110) are here given in the order, *cab*, corresponding to the M_2-orientation of the crystal. Similarly the symbol $10(101)S(M_1)$ of the face V refers to the normal or M_1-orientation of the crystal with the c-axis vertical and the plane of the gnomonic projection drawn perpendicular to the c-axis; 10 is the Goldschmidt symbol of the face V in this orientation, and (101) is the Miller symbol with the indices in the usual order, *abc*.—G. T. and C. J. K.
[32] Op. cit., p. B228.

$\beta(310)$, indice 2, obliquité 4° 16′; moins probable; macle $p(111)$, indice 3, obliquité 5°11′; la moins probable."

Thus the fundamental rôle of the *S*-elements in the crystallography of calaverite has emerged both from observations with the reflection goniometer and from analysis of photographs taken with the Weissenberg X-ray goniometer. However, certain features in the morphology and in the X-ray diffraction patterns of calaverite are not explained by the *S*-lattice, and attempts to elucidate them have resulted in numerous hypotheses, which will be discussed briefly in this paper, after these unusual features have been described.

The peculiarity in the morphology of calaverite, which has been observed by all investigators who have studied it with the reflection goniometer, is that only a minority of its forms receive simple indices when referred to the *S*-elements. Thus of the 92 established forms only 12 (of which, however, 6 occur among the 11 most frequently observed forms as listed by G. P. & P.[33]) are simple *S*-forms. One of the most frequently occurring forms is that designated *C* by G. P. &. P., which consists of a pair of faces on each termination, each of these faces making an angle of 7°53′ with the clinopinacoid, *b*. The two face-poles of the form *C* that are situated near the projection of the positive end of the *b*-axis appear to lie each at the intersection of 2 zones through frequently occurring *S*-forms; one of the face-poles lies at the intersection of a zone through the *S*-faces 304 and 111 with a zone through the *S*-faces 801 and 110; the other face-pole lies at the intersection of a zone through the *S*-faces $\bar{3}0\bar{4}$ and $\bar{1}1\bar{1}$ with a zone through the *S*-faces $\bar{8}0\bar{1}$ and $\bar{1}10$. Thus, according to G. P. & P., the form *C*, considered as an *S*-form, has the rational but complicated symbol, $(\bar{5}.29.3)$. In the gnomonic projection of calaverite constructed on the plane perpendicular to the symmetry axis (*b*-axis), the 80 complex forms lie partly in zones connecting the 2 "singular nodes" *C*, with the *S*-forms *p* and *w*, and the remainder in two families of zones parallel with the *CS* zones [*Cp*] and [*Cw*].[34,35] All the forms of calaverite except 12 *S*-forms receive symbols of great complexity on the *S*-elements. However, it had been found by Smith, that the complex faces possess zonal relations, and that in the various zones even the complex faces are almost invariably distributed in accordance with the law of simple, anharmonic ratios. The mutual relations of the complex faces were found to be such that, by constructing other sets

[33] Op. cit., Table 31, p. 48.
[34] G. P. & P., op. cit., p. 21.
[35] All letters used to designate faces of calaverite crystals in this paper are those of G. P. & P. unless otherwise noted.

of axes than those used by Penfield and Ford, and referring one group of faces to one set of axes and other groups to other sets of axes, Smith was able to assign relatively simple indices to most of the forms. He[36] concluded that "five distinct lattices may be traced in calaverite, which are incongruent but not independent. The prism zone is common to all." These results of Smith were extended by G. P. & P., who found that, besides the *S*-elements, 4 sets of *C*-elements are needed, 3 of the 4 sets of *C*-elements being repeated by the symmetry axis (*b*-axis) to give a total of 7 sets of *C*-elements, and a grand total of 8 sets of elements, including the *S*-elements. Of these, all except the *S*- and C_0-elements are triclinic. However, even with the 8 sets of elements "There remain a number of prismatic forms (CC_2-forms) which lie in zone with the base *C* (001) of the C_1-elements and with nodes of the incongruous C_2-elements. These forms are therefore incongruous to both groups of elements and cannot be given simple symbols."[37] In other words even with 8 sets of elements there remain faces, some of them important[38] ones, that cannot be given simple indices. For this reason Peacock[39] concluded that: "It is of no value to express these groups of elements [i.e. the polar *C*-elements.—G. T. and C. J. K.] as triclinic linear elements. The linear constants do not show the close relations which exist between the several groups of polar elements, and they would imply a triclinic interpretation of calaverite which we reject." G. P. & P. found that, not only are the angular relations in the complex zones such that the law of simple, anharmonic ratios is satisfied, but in addition the distribution of the faces in the complex zones appears to conform closely with Goldschmidt's "law of complication." In their view "The singular node pair *C* was the key to the calaverite puzzle. When it was recognized that the node *C* with its complicated symbol was yet the simplest node, namely the node of origin (0), in each zone containing *C*, and that every zone of calaverite gave a more or less complete N_3 complication series[40] without extra terms, it was apparent that calaverite conformed strictly to the Law of Complication as it was formulated many years ago."[41] They also concluded that "no admissible assumptions of twinned or heterogeneous structure will serve to bring this

[36] G. F. Herbert Smith, op. cit., p. 140.
[37] M. A. Peacock, op. cit., p. 327.
[38] So regarded by G. P. & P. (op. cit., p. 52), also by the present writers.
[39] Op. cit., p. 327.
[40] A clear statement of what is meant by an N_3 complication series was given by Peacock on pages 319–320 of the article from which this quotation is drawn.
[41] M. A. Peacock, op. cit., p. 323.

crystal species within the Law of Rationality in its generally accepted form."[42]

ADVENTIVE DIFFRACTION SPOTS AND THEIR RELATION TO THE COMPLEX FACES OF CALAVERITE CRYSTALS

In our röntgenographic investigation of calaverite we of course expected to obtain information as to whether or not the morphological C-lattices have structural counterparts as well as the morphological S-lattice. From our rotation and Weissenberg photographs we find only one structural lattice in calaverite. However, in addition to the diffraction spots on our rotation and Weissenberg negatives corresponding to planes of the structural lattice (analogous to the morphological S-lattice), there are present certain other diffraction spots (of weak intensity but nevertheless quite distinct) which we term adventive diffraction spots. These adventive diffraction spots cannot be ascribed to planes of the structural lattice; if it were assumed that the adventive diffraction spots are produced by planes belonging to the structural lattice, it would be necessary to conclude that the unit cell of calaverite contains not 2 *molecules* of $AuTe_2$ but a number many times greater, and in this case there would be an enormous number of planes that might give diffraction effects on our films, but from which no diffraction effects are present. Thus the assumption of a larger unit cell than that determined by Tunell and Ksanda[43] is incompatible with the observed planar spacings. There are other equally cogent reasons for stating that the adventive difraction spots are not produced by planes of the structural lattice. Thus, although no crystal has been found by us that does not yield some adventive diffraction spots, nevertheless a large proportion of the adventive spots present on the rotation and Weissenberg films of one calaverite crystal are missing on the corresponding films of another calaverite crystal, whereas, of course, the diffraction spots from the planes of the structural lattice are present on the films of all the calaverite crystals investigated, and spots from analogous structural planes of different crystals have approximately the same intensities. On the first layer-line of one calaverite crystal (rotation around the b-axis) there is a large number of adventive diffraction spots and on the equator of the same crystal (rotation around the same axis) there are a few; on the first layer-line of another crystal (rotation around the same axis) there are only 2 adventive diffrac-

[42] M. A. PEACOCK, op. cit., p. 318.
[43] Op. cit., p. 33.

tion spots, and on the equator (rotation around the same axis) of this crystal there is none. Moreover we have made a considerable number of powder photographs of calaverite crystals with Cu-, Fe-, and Cr-radiation and have found on them no adventive lines but only lines corresponding to planes of the structural lattice. This result is not surprising in view of the fact that the adventive spots on the X-ray photographs of single crystals are of relatively weak intensity. On the rotation photographs taken around the *b*-axis and Weissenberg photographs taken around the *b*- and *a*-axes it can be seen that the adventive spots are mostly confined to the layer-lines of the *b*-axis photographs although a few occur between them. From this it follows that if the diffraction planes giving rise to the adventive diffraction spots were indexed on the structural axes (analogous to the morphological *S*-axes) most of these planes would have small whole numbers as values of *k* in their symbol, *hkl*. On 180°-oscillation and Weissenberg photographs taken around the *a*-axis it appears that most of the adventive spots occur between the layer-lines of the *a*-axis photographs; thus if the diffraction planes giving rise to the adventive diffraction spots were indexed on the structural axes, most of these planes would not have whole numbers as values of *h* in their symbol, *hkl*. In the drawings of the reciprocal lattice layers constructed by the method of Schneider[44] it is observed that the points corresponding to the adventive spots nearly all satisfy the requirements of the two-fold symmetry axis; however, the adventive diffraction spots are almost all weak and in some cases one occurs without the corresponding spot required by the symmetry axis. Most of the diffraction planes yielding the adventive spots are represented, on a gnomonic projection perpendicular to the *b*-axis, by poles that lie outside the area in which the poles of the faces measured by G. P. & P. are situated, and therefore cannot be correlated closely with the observed faces. Of the diffraction planes the poles of which lie within this area, a number can be correlated directly with observed complex faces (*C*-faces); several others are related to zones observed by G. P. & P., although they do not correspond to faces actually observed. On the first and second layer-lines (rotation around the *b*-axis) a number of adventive spots of weak intensity are present from diffraction planes parallel to complex faces (*C*-faces) observed by G. P. & P., and on the second layer-line (rotation around the *b*-axis) there are also present a few weak adventive spots representing diffraction planes the poles of which lie in complex zones observed by

[44] W. Schneider, Zeit. f. Krist., **69**: 41–48. 1928.

G. P. & P., and midway between poles of faces observed by them. The remaining adventive spots that represent diffraction planes the poles of which occur in the area in which the poles of the observed faces lie, cannot be correlated with the observed faces in any simple or direct way. Smith[45] and G. P. & P.[46] found that in their composite gnomonic projections of the crystal faces of calaverite, many of the zone-lines passing through the poles of complex faces include a considerable number of face-poles; they also found that these poles of complex faces are spaced at equal intervals along a given zone-line, or, in some cases, at rational sub-multiples or multiples of the unit interval. Since each layer of the reciprocal lattice can be regarded as a gnomonic projection of all the crystal planes having one Miller index in common, the question arose whether or not lines could be drawn through the poles of the adventive diffraction planes (in a layer of the reciprocal lattice perpendicular to the *b*-axis) in a manner similar to the zone-lines through the poles of the complex faces. It was found that if lines are drawn through the poles of the adventive diffraction planes in such a layer of the reciprocal lattice (one perpendicular to the *b*-axis), very few lines contain more than two poles of adventive diffraction planes. Of course, if all the reciprocal lattice-layers were combined in a single gnomonic projection, the number of poles of adventive diffraction planes lying along some lines would be increased. However, there is a striking contrast between the results of the morphological and röntgenographic investigations in that, whereas in the composite gnomonic projection of the external faces of calaverite only 12 simple *S*-forms are represented, on our Weissenberg negatives taken by means of Cu-radiation with the crystal rotating around the *b*-axis there are represented structural planes corresponding to 66 potential as well as to all the 12 observed morphological simple *S*-forms except *A*(304) and *b*(010). Of these remaining two observed morphological simple *S*-forms the plane 010 yields diffraction effects on other films; the plane 304 cannot yield a first order diffraction line in the space-groups possible for calaverite, and the spacing of this plane is too small for the second order diffraction line to be theoretically possible with Cu-radiation. At the same time the great majority of the *C*-forms (complex calaverite forms), which predominate in the composite gnomonic projection of the external faces as yet have not been found represented among the adventive diffraction planes.

[45] Op. cit., p. 136, also Fig. 3 on p. 137.
[46] Op. cit., pp. 21–22, also Plate III.

The presence of the adventive diffraction spots on the Weissenberg photographs of calaverite crystals of course raised the question whether the crystals might not be aggregates of differently oriented grains of calaverite or mixtures of calaverite with some other mineral. The analysis of the Weissenberg photographs has proved, however, that the crystals cannot be explained as aggregates of differently oriented grains of calaverite; this analysis has shown that each of our apparently single crystals contains only one structural lattice, and that the adventive diffraction spots from such a crystal cannot be referred to subsidiary grains repeating the same lattice in different orientations, since the spacings of some of the diffraction planes producing the adventive diffraction spots are different from the spacings of any planes in the calaverite structural lattice.[47]

MICROSCOPIC EXAMINATION OF POLISHED SURFACES OF CALAVERITE

In an attempt to find out whether or not the calaverite crystals contain particles of some other mineral, we have examined polished surfaces of several of our crystals under the reflecting microscope.[48] Polished surfaces were made parallel and perpendicular to the *b*-axis and were examined with and without crossed nicols at medium (240×)[49] and high (900×)[50] magnifications; no inclusions or impurities could be found, and no twinning lamellae, or any other indication that the crystals are not in reality single crystals.[51] We have not excluded the possibility, of course, that a second phase or mineral may be present in a very finely dispersed condition in the calaverite, the individual particles of the disperse phase not being visible with the polarizing microscope, but the presence of such a disperse phase does not appear probable.

[47] For the purpose of indexing the lines of our powder photographs of calaverite we have computed the spacings of all planes in the structural lattice that are greater than 1.000 Å, and have arranged the results in a table of decreasing spacings. The spacings of several of the diffraction planes producing the adventive spots were computed from measurements on the Weissenberg negatives and compared with the spacings in this table.

[48] The authors are greatly indebted to Prof. L. C. Graton and Dr. E. B. Dane, Jr., of Harvard University, and to Dr. J. W. Greig of the Geophysical Laboratory for their kind assistance in the preparation and examination of the polished surfaces, and for the use of their polishing equipment and reflecting microscopes.

[49] The medium power objective was a Leitz 8 millimeter dry apochromat.

[50] The high power objective was a Zeiss 2 millimeter oil-immersion apochromat.

[51] One crystal of calaverite from Cripple Creek, kindly supplied by Prof. Charles Palache and Dr. M. A. Peacock of Harvard University, showed two differently oriented parts when a fragment of it was ground and polished and examined under the reflecting microscope; the differently oriented parts were easily detected between crossed nicols.

HYPOTHESES SUGGESTED BY PREVIOUS AUTHORS TO EXPLAIN THE PECULIARITIES OF CALAVERITE

Although the morphological observations of Smith and of G. P. & P. are in close agreement, the physical interpretation suggested by Smith was not accepted by G. P. & P. Smith concluded that the coexistence, at any point of a crystal, of the five morphological lattices constructed by him from his goniometric measurements would imply heterogeneity of the crystal. Thus he[52] wrote: "The only hypothesis remaining appears to be the existence of a minute skeletal structure of some kind—an infinitesimal framework composed of material with an arrangement according to one lattice intercalated with material with an arrangement according to another lattice. Since the lattices, while not congruent with one another, have a zone in common, i.e. the rows parallel to its edge equidistant, or at least congruent, in parallel planes, and have other relations, . . . interaction at some of the boundaries separating the differently constituted sections would seem to be indicated. This hypothesis is in harmony with the suggestion made above as to the origin of the brittleness of the crystals.[53] The frequent occurrence of pits on the faces, and the existence of skeletal and hollow crystals, suggest breaks in continuity of the homogeneous arrangement." G. P. & P. also recognized the apparent coexistence of several morphological lattices, but in view of the close relationships found between these lattices, they concluded that all the lattices pertain to a *single* crystal. According to the interpretation of G. P. & P. the faces of a single crystal of calaverite cannot all be given simple indices; however, even the assumption of Smith that the crystals are really finely heterogeneous and contain several lattices, does not result in the assignment of simple indices to all of the important faces. Moreover, Smith himself recognized that the crystals could well be interpreted as monoclinic single crystals, or in some cases as simple monoclinic twins, except for the fact that such an interpretation would result in complex indices for most of the common forms. Thus as Smith[54] well stated: "We have a morphological development of the face which is completely in accord

[52] G. F. HERBERT SMITH, op. cit., p. 143.

[53] Smith's suggestion as to the origin of the brittleness of calaverite was as follows (op. cit., p. 143): "If the crystals are composed of two or more individuals so intimately intermixed that the separation is not visible to our perceptions, and if each individual has a cleavage in corresponding but not parallel directions, the brittleness would be explained: and further, if the constituent individuals at particular points are sufficiently small, the fractured surfaces would not give distinct and definite reflections; the surfaces in fact give a blur of light."

[54] Op. cit., p. 141.

with monoclinic symmetry. This view of the symmetry is confirmed by the frequent occurrence of a faces of the form *Y* [the clinopinacoid, *b*, according to Goldschmidt, Palache, and Peacock.—G. T. and C. J. K.], which invariably gives a single distinct image, and not one blurred or double, such as would be expected did it really belong to two or more separate individuals. The faces also occur in positions similar to those of their poles on the sphere of projection, and there are none of the markings or re-entrant angles (beyond those in the prism zone)[55] which usually accompany twinning, however much concealed. Later on, when we proceed to consider twin crystals, we shall find that the planes of twinning except that of the fourth, a doubtful type, have simpler indices on the hypothesis of monoclinic symmetry." However, the fact that this interpretation would necessitate the assignment of complex indices to most of the common and best developed faces, caused Smith to explore the possibilities that might lie in the hypothesis of heterogeneity.

The hypothesis that calaverite crystals may be heterogeneous on a very fine scale—we now know that the subsidiary particles, if present, must be very small and were not visible with the microscope—cannot be entirely laid aside as yet, but we can now be sure that each of the apparently single calaverite crystals has one main individual the structural lattice of which is analogous to the morphological lattice first found by Penfield and Ford, and retained by G. P. & P. as the fundamental morphological lattice of calaverite (the *S*-lattice).

Recently Borchert[56] concluded from studies of polished surfaces of calaverite and krennerite with the reflecting microscope, that calaverite is the high temperature modification and krennerite the low temperature modification of the same compound. He observed lamellae in some crystals of calaverite from Cripple Creek, Colorado, which were rendered easily visible by the use of crossed nicols and etching reagents, such as aqua regia.[57] These lamellae were interpreted by Borchert as having been formed during a polymorphic inversion. He regards the faceted, apparently single, crystals of calaverite as paramorphs having the internal structure of krennerite (Borchert refers to the faceted, apparently single, crystals of calaverite as "Original-α-Calaverit" and to krennerite as "primärer β-Cala-

[55] Smith states elsewhere in the same article (p. 122) that the re-entrant angles in the prism zone are due to its oscillatory and striated character.

[56] H. Borchert, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **69**, Abt. A: 466–472. 1935.

[57] H. Borchert, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **61**, Abt. A: 106–116. 1930.

verit"). Borchert[58] also concluded that: "Die Frage der Kristallsysteme [of krennerite and calaverite] muss einstweilen offen gelassen werden. Dagegen kann doch festgestellt werden, dass die Untersuchungen von V. Goldschmidt, Ch. Palache und M. Peacock sich gut mit der naheliegenden Auffassung in Einklang bringen lassen, dass sich die singulären Knoten, die ein sylvanitähnliches Punktsystem mit einem Hauptknoten überlagern, aus der stattgehabten Paramorphose erklären und dass das Gesetz der rationalen Indizes als allgemeiner Ausdruck regelmässigen Gitterbaues keine Einbusse zu erleiden braucht."

It has been proved, however, by our work that Borchert's hypotheses are quite untenable. Our faceted, apparently single, crystals of calaverite from Cripple Creek, Colorado, have undergone no polymorphic inversion and are not paramorphs. We have proved that the structural axes of our calaverite crystals coincide in direction with their morphological axes, also that the axial ratio calculated from the dimensions of their structural unit cell agrees within the limit of error with the axial ratio of calaverite determined morphologically by G. P. & P. Moreover, no lamellae have been found in our crystals, although a careful search was made for evidence of heterogeneity in oriented polished surfaces with and without crossed nicols and with medium and high power objectives, also by etching the polished surfaces with aqua regia and concentrated nitric acid. It is quite possible, of course, that some calaverite crystals contain lamellae such as those described by Borchert; however, Borchert's hypothesis is that all calaverite (Original-α-Calaverit) crystals have passed through a polymorphic inversion and he states that the lamellae produced by this inversion are easily discernible optically.[59] The correlation of the röntgenographic analysis of our calaverite crystals with the measure-

[58] Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **69**, Abt. A: 469. 1935.

[59] Borchert writes (Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band **69**, Abt. A: 468. 1935): "Entscheidend für α-Calaverit sind die wohl nie ganz fehlenden Anzeichen für die stattgehabte Umkristallisation," and on the same page, "Die leichte oder schwere Erkennbarkeit der Lamellen bildet neben ihrer äusseren Form und Anordnung einen weiteren charakteristischen Unterschied zwischen Original-α-Calaverit und primärem β-Calaverit. Die Zerfallslamellen sind optisch leicht sichtbar, während die Verzwilligung beim β-Calaverit offenbar gewöhnlich nach einem Gesetz erfolgt derart, dass die optische Orientierung der Lamellen nur sehr wenig verschieden ist." On page 472 of the same article he adds, "Die Lagerstätten von Cripple Creek und von Săcărâmb (Nagyag) führen sowohl α- wie auch β-Calaverit; genauer, es kommt neben dem lamellaren Calaverit, der ursprünglich als α-Modifikation entstanden ist, auch der primär rhombische vor. (Ob die Einordnung in die verschiedenen Kristallsysteme zutreffend ist oder nicht, spielt dabei für die Auswertung der allotropen Umwandlungen keine Rolle.) Im Cripple Creek-Distrikt herrscht offenbar der lamellare Calaverit vor, der ja in Form von Einzelkristallen von diesem Fundpunkt in allen grösseren Sammlungen vertreten ist."

ments made on the same crystals with the two-circle reflection goniometer proved that each crystal, apparently single as judged by the development of its external faces, contains but one structural lattice. We have also shown that, if the adventive diffraction spots are due to the presence of particles of a disperse phase, then, from the distribution and intensities of the adventive diffraction spots and from our microscopical studies, these particles must be individually very small and must constitute altogether only a minor part of the crystals; certainly even if such particles are present they afford no reason to suppose that the crystal has passed through a polymorphic inversion, but rather must constitute some unusual type of intergrowth.

Finally Borchert's hypothesis that calaverite (Original-α-Calaverit) is identical structurally with krennerite (primärer β-Calaverit) as a consequence of a polymorphic inversion having occurred in the calaverite (Original-α-Calaverit) has also been disproved. Well developed, faceted crystals[60] of krennerite previously measured on the two-circle reflection goniometer were investigated on the Weissenberg X-ray goniometer by the equi-inclination method. Although the röntgenographic analysis has shown that the unit length of one axis of krennerite (the *c*-axis of vom Rath) corresponds quite closely with the unit length of the *b*-axis of calaverite, the other axes of the two minerals are quite different. The volume of the unit cell of krennerite is approximately 4 times the volume of the unit cell of calaverite.[61] The powder photographs of the two minerals are very similar, and the rotation photograph of krennerite taken around the *c*-axis of vom Rath bears a rather close resemblance to the rotation photograph of calaverite taken around the *b*-axis; in addition to the similarity between the spacings of the layer-lines there is a close similarity in the spacings and intensities of some, although by no means all, of the spots along the layer-lines. However, the Weissenberg photographs of corresponding layer-lines of these rotation photographs of the two minerals are very different indeed, and leave no doubt that the structures of calaverite and krennerite are not the same.

A new type of crystal intergrowth has been suggested by Donnay[62] as a possible explanation of the morphological peculiarities of calaverite. He observed a geometrical relationship previously unrecognized in the morphology of calaverite, namely, that the gnomonic poles of the faces (complex faces as well as simple *S*-faces) are, with few ex-

[60] Kindly supplied by Professor Charles Palache and Dr. M. A. Peacock of Harvard University, to whom the authors wish to express their appreciation.
[61] Cf. G. Tunell and C. J. Ksanda, this Journal, **26**: 507–509. 1936.
[62] Op. cit.

ceptions, distributed in adjacent parallel belts of equal width, that can be alternately referred to two, non-interpenetrating, plane nets. This observation led him to the hypothesis that the apparently single crystals of calaverite each consist of two intergrown triclinic lattices mutually oriented according to a definite law.

A principal difficulty in correlating our röntgenographic results with Donnay's hypothesis that the apparently single crystals of calaverite consist of an intergrowth of two triclinic lattices is that we have not been able to obtain any diffraction effects from the planes taken by Donnay as pinacoids in his two triclinic lattices except the plane *E*, the front pinacoid in both of his lattices. The plane *E* is a plane of our structural lattice having the symbol 801; a diffraction effect is obtained from this plane, but the spacing of this plane is small and it is not a principal plane of the structural lattice. A second difficulty is that, for the reasons stated in the preceding pages, we find it impossible to combine the points in reciprocal space corresponding to the adventive diffraction spots with the points in reciprocal space corresponding to the monoclinic structural lattice to form one or more triclinic reciprocal lattices.

CONCLUSION

The complex faces characteristically present on crystals of calaverite have been found to be related, at least in part, to certain adventive diffraction spots in the X-ray spectra of these crystals. Along with the complex faces there are commonly present a number of simple faces (*S*-faces). We have previously described the crystal structure of calaverite, which has the symmetry of the monoclinic system, and pointed out that the structural elements are analogous to the fundamental morphological elements of Goldschmidt, Palache, and Peacock (their *S*-elements). The structural lattice is thus closely related to the simple crystal faces designated by Goldschmidt, Palache, and Peacock the *S*-faces. A complete explanation has not yet been found for the complex faces or the adventive diffraction spots. It appears probable that the solution of the problem presented by these unusual features will not be found in the geometrical arrangement of the 2 gold and 4 tellurium atoms in the structural unit cell of calaverite, but rather in some type of subsidiary phenomenon in the crystals.

Oriented polished surfaces of calaverite crystals were examined by us with reflected light. No inclusions, or twinning, or any kind of departure from perfect homogeneity were visible under the polarizing microscope.

ACKNOWLEDGMENT

The authors are indebted to Prof. Charles Palache, Dr. M. A. Peacock, and Prof. L. C. Graton of Harvard University, Dr. J. D. H. Donnay of the Johns Hopkins University, and Dr. H. E. Merwin of the Geophysical Laboratory for reading the manuscript of this paper and making several valuable suggestions.

PALEONTOLOGY.—*A new crassatellid from the Waccamaw formation of North and South Carolina and the Caloosahatchee marl of Florida.*[1] F. STEARNS MACNEIL, U. S. Geological Survey. (Communicated by JOHN B. REESIDE, Jr.)

While attempting to identify a crassatellid from the Intracostal Waterway, 3 miles west-southwest of Little River, S. C., the writer found that specimens from the Pliocene of the Carolinas, previously identified as *Crassatellites gibbesii* (Tuomey and Holmes), include, in addition to that species, another well defined species which is described below as new.

As has been pointed out by Lamy, Iredale, and Stewart, the name "*Crassatellites*" Krueger is based on rather uncertain grounds. Its acceptance depends on whether *Crassatella* Lamarck is a synonym of *Mactra*, and, if so, whether Krueger's genera are valid or are to be interpreted as a special nomenclature, i.e. the addition of *ites* for a fossil form. At any rate, "*Crassatellites*," if valid, is an Eocene shell and not confusable with American Miocene to Recent crassatellids.

Stewart proposed the expansion of the Australian genus *Eucrassatella* Iredale to include Miocene to Recent American forms having smooth internal margins and large ligamental cavities, and described the subgenus *Hybolophus* for the opisthogyrate *Crassatella gibbosa* Sowerby from the west coast. *Eucrassatella* agrees more closely with the American forms in shape and hinge characters, but does not have the flat, often turned-over umbos characteristic of the American forms. *Hybolophus gibbosa* has flat, turned-over umbos, but is so extreme in other ways that it appears to be at least subgenerically removed from other American species. It may be that the American species are in need of a new generic name but that could be given conscientiously only after a systematic study of all Tertiary crassatellids had been made and then, probably, on phylogenetic grounds. For the present the American forms will be referred to the genus *Eucrassatella*.

[1] Published by permission of the Director of the U. S. Geological Survey. Received October 12, 1936.

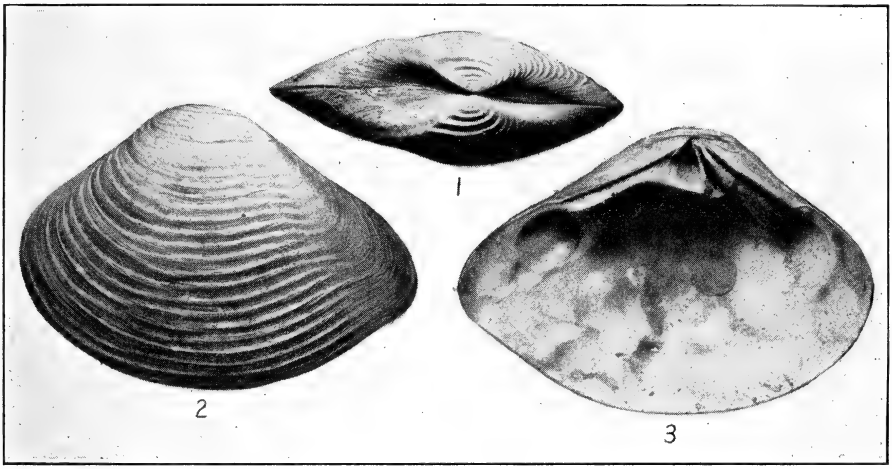
Eucrassatella mansfieldi MacNeil, n. sp.

Shell subtrigonal, moderately inflated, anterior rounded, posterior more produced and sub-angulate; umbonal ridge bounded anteriorly by a well-developed sulcus; beaks just anterior of center and slightly opisthogyrate, flattened and horizontal or slightly turned over; sculpture consisting of coarse, concentric undulations, about 35–40 in number in full grown adults, which, until the shell is half grown, terminate at the umbonal ridge, but in adults terminate in the sulcus.

Dimensions of holotype: Length 61 mm, height 42.5 mm, convexity 10 mm. Largest paratype: Length 77 mm, height 56.5 mm, convexity 14 mm.

Holotype: U. S. Nat. Mus. Cat. no. 495195. Paratypes: 495196.

Type locality: Highest bed at Neill's Eddy Landing, right bank of Cape Fear River, 5 miles northeast of Acme, Columbus County, N. C., U. S. G. S. Sta. 4276.



Figs. 1–3.—*Eucrassatella mansfieldi* MacNeil, n. sp., highest bed at Neill's Eddy Landing, right bank of Cape Fear River, 5 mi. northeast of Acme, Columbus Co., N. C., U. S. G. S. Sta. no. 4276. 1.—Paratype, U. S. Nat. Mus. Cat. no. 495196. 2–3.—Holotype, U. S. Nat. Mus. Cat. no. 495195.

Other occurrences in the Carolinas: Upper bed on the north shore of Lake Waccamaw, N. C.; Acme, N. C.; Cronly, N. C.; Intracostal Waterway, 3 miles west-southwest of Little River, S. C.

E. mansfieldi differs from *E. gibbesii* (Tuomey and Holmes) in being relatively more elongate and less high, and in having coarser and fewer ribs. Specimens of *E. mansfieldi* and *E. gibbesii* of about equal size have about 31 and 55 ribs respectively. The flattened area of the beaks is larger in *E. mansfieldi*.

This species and *E. gibbesii* were both collected along the spoil bank of the Intracostal Waterway but with a matrix of different texture adhering and may be from different beds. *E. mansfieldi* is the only species collected at the localities in North Carolina listed above.

E. gibbesii is also present in the collections in the U. S. National Museum from the following localities: Tilly's Lake, Waccamaw River, S. C.; Wilmington, N. C.; 2 miles north of Padgett, Onslow County, N. C.

Neither species has been collected from the Walker's Bluff locality on the Cape Fear River, 18 miles east-southeast of Elizabethtown, N. C., but two eroded valves of *E. undulatus* (Say) which may be reworked from the Miocene are in the collection from there.

One small valve probably referable to *E. mansfieldi* is in the collection from the Caloosahatchee marl of south western Florida, from near the head of Prairie Creek, a tributary of Shell Creek which flows into Charlotte Harbor, U. S. G. S. Sta. no. 3300.

The more abundant species at the Shell Creek and Alligator Creek localities of the Caloosahatchee marl of southwestern Florida is of the *E. gibbesii* type but is more like Recent specimens from Florida than Pliocene specimens from North Carolina. It is probable that *E. floridanus* (Dall) which he later placed in synonymy with *E. gibbesii* is the valid name for the Recent species and that the Shell Creek and Alligator Creek forms should be referred to it.

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BOTANY.—Tetracoccus ilicifolius, *a new shrub from Death Valley, California.*[1] FREDERICK V. COVILLE and M. FRENCH GILMAN.

In exploring new canyons in Death Valley, California, during the last three seasons, in connection with his work for the National Park Service, Mr. Gilman has found nearly 50 species of plants hitherto unknown in that desert area. In May, 1936, in the large canyon on the west side of the Grapevine Mountains, next north of Titus Canyon, he discovered a new shrub seemingly unrelated to any other plant of the region. The hollylike form of the evergreen leaves, an inch or less in length, lead to the suggestion of hollybush as the common name of this shrub.

Further features of the plant are that the capsule has the unusual number of 4 cells, each cell containing 2 ovules, that the leaves are opposite, and that the plant is dioecious. These characteristics, together with the absence of a corolla, indicated a relationship with *Tetracoccus dioicus*. That plant is the only species of the genus *Tetra-*

[1] Received September 3, 1936.

coccus, of the family Euphorbiaceae, subfamily Phyllanthoideae, and is very rare, being known only from a few localities in northern Lower California, and in the vicinity of San Diego, California. Not only in technical characteristics do the two plants resemble each other, but also in such intimate characteristics as leaf texture and the peculiar hairs of the pubescence. The Death Valley plant is here described as a new species of *Tetracoccus*.

Tetracoccus ilicifolius, sp. nov.

Frutex dioicus, cortice griseo; folia opposita, uncialia, ovato-lanceolata, coriacea, dentata, iliciformia, viridia, sempervirentia, juventate levissime stramineo-villosa, anno altero glabra, petiolo 1–2 mm longo, stipulis nullis; inflorescentia lateralis bractearum caducarum axillis ad ramorum novorum basim; flores apetali; masculi axe aut ramulis brevibus inflorescentiae subuncialis fasciculati, 2–3 mm longi, sepalis et staminibus 7–9; feminei solitarii, pedunculo bibracteolato; sepala 8, in fructu immaturo 3–5 mm longa, herbacea, appressa, acuminata, parce stramineo-tomentosa, marginibus imbricatis, 4 exteriora lanceolata vel ovata, 4 interiora ad basim angustiora; capsulae immaturae oblongo-orbiculares, stramineo-tomentosae, 7–8 mm longae, 4-loculares, ovulis in loculo quoque 2; styli 4, 2–3 mm longi, ad apicem latiores, apice interdum incurvati, in apicem capsulae immaturae divaricate appressi.

Plant a dioecious shrub, 0.3 to 1.3 meters in height; twigs of the season purplish, sparingly villous with pale brown, flexuous hairs, the twigs of the preceding season purplish and smooth, those of earlier seasons gray; leaves opposite, evergreen, in the second year usually deep green above and paler beneath, 2.5 to 1.5 cm in length or sometimes even smaller, thick, coriaceous, ovate-lanceolate to ovate, with as many as six teeth on each margin, resembling the leaves of *Ilex aquifolium* and *Ilex opaca*, broadly acute at the apex, rounded at the base, pinnately veined, sparingly villous with pale brownish hairs on both surfaces when young, smooth in the second year, on stout petioles 1 to 2 mm long, without stipules; flowers apetalous, borne toward the leafless base of new twigs of the season, on peduncles from the axils of caducous bracts; male flowers numerous, in clusters less than 2 cm long, fasciculate on the main axis or on short lateral branches, with 7 to 9 lanceolate smooth sepals 1 mm or less in length, and 7 to 9 stamens 2 to 3 mm long, the filaments slender and smooth, the anthers about 0.7 mm long, nearly as broad, 2-celled, extrorse, dehiscing longitudinally, attached to the filament at a point a little below the middle of the anther, the main axis of the male inflorescence and its branches sparingly villous with pale brownish, flexuous hairs, some of them gland-tipped; female flowers borne singly and terminally on leafless peduncles, one or two on each flowering twig, the peduncle commonly 6 to 8 mm long, bibracteolate, with pale brownish hairs; sepals 8, on the immature fruit 3 to 5 mm long, green, appressed to the base of the capsule, acuminate, sometimes minutely toothed, tomentose with pale brownish hairs, the margins thinner and somewhat imbricated, the exterior four lanceolate or ovate, the interior four narrower toward the base; disk with a body 3 mm in diameter in the immature fruit, and an additional margin of irregular papilliform teeth, the body of the disk often splitting into four parts; capsule immature in our specimens, tomentose with pale brown-

ish hairs, oblong-orbicular in outline, 7 to 8 mm long, 4-celled, with 2 ovules in each cell, the ovules pendant from a point near the summit of the central axis and about one-third the distance from the top of the cell to the base; styles 4, distinct, 2 to 3 mm long, divaricately appressed against the summit of the immature capsule, wider and flattened above the middle and sometimes incurved at the apex; seeds usually 2 in each cell, the body of the seed 4.5 to 4.7 mm long, about 2.5 mm wide and 1.5 mm thick, smooth and shining, narrowed and rounded at the lower end, narrowed and broadly acute at the upper end, the hilum about a third the distance from the top of the seed body to its lower end, a strophiole, 1.5 mm in length, extending diagonally from a point just above the hilum to and slightly beyond the upper end of the body of the seed; embryo straight and endosperm thin, the two cotyledons flat and thin, 2 mm wide by 3 mm long, the radicle extending beyond the hilum into the acute apex of the body of the seed.

Type specimen in the United States National Herbarium, no. 1,650,292, collected in Death Valley, California, at an altitude of about 2,000 feet, in the large canyon north of Titus Canyon, on the west slope of the Grapevine Mountains, May 30, 1936, by M. French Gilman (no. 2180). An additional specimen with the same data is Gilman 2181.

The bushes grew chiefly in crevices in the rock wall of the canyon, which at this point consists of rhyolite. Only eleven plants were found on the first visit, May 30, 1936. On a later visit, August 2, 1936, to get mature seeds if practicable, Mr. Gilman, after very careful search, located four additional plants, one of them half-dead.

The day selected for this second visit was expected to be cool, but the official Weather Bureau maximum shade temperature at Furnace Creek Ranch, in the bottom of Death Valley, known in the Weather Bureau records as Greenland Ranch, was 125° Fahrenheit.

Of the fifteen known plants of this species only two have been definitely ascertained to be pistillate, and only one of the two matured its fruit in 1936.

The individual bushes vary in height from a foot to four and a half feet. They grow in cracks in the rock, and as is usual with shrubs in such a situation, they have an enlarged base from which spring the stems. These are ordinarily three-fourths of an inch to an inch in diameter at the base, in the largest plant reaching about 2 inches. The color of the bark is light gray. The bushes are not dense, like many desert shrubs, but of an open growth and irregular shape. Their breadth is greater than their height. A bush 3 feet high was 5 feet across, and the largest bush, 4.5 feet high, was 8 feet across. This largest bush grew in a large vertical crack that provided it with more soil than the other plants, and several cross cracks collected for it an unusual amount of moisture from the few and scant rains in Death Valley.

Tetracoccus was proposed in a manuscript note by George Engelmann as a new genus name for some specimens with immature fruit collected by C. C. Parry in February, 1883, near Table Mountain, Lower California. Dr. Engelmann, whose death occurred February 4, 1884, did not himself publish the description, but additional specimens with staminate flowers and mature fruit having been collected by C. R. Orcutt September 24, 1884, on hills

near Santo Tomás, Lower California, a description of the genus was published by Sereno Watson on February 21, 1885.[2] Dr. Watson said that the examination of the Parry specimens of *Tetracoccus* probably was Dr. Engelmann's last botanical work. To the generic description Dr. Watson added a description of the species under the name *Tetracoccus engelmanni.*[3] However, a description of the genus had been published a few days earlier,[4] by Parry, who named the species *Tetracoccus dioicus.*[5] Both Parry's and Watson's descriptions were based on the same collections.

In 1906 T. S. Brandegee described a *Tetracoccus hallii*[6] from the Colorado Desert, southeastern California. This plant, however, has a 3 celled ovary, and in neither habit nor pubescence does it resemble *Tetracoccus dioicus.* In 1923 I. M. Johnston took *hallii* out of *Tetracoccus* and placed it, along with two other species previously referred to the genus *Securinega,* in a new genus, *Halliophytum.*[7] Prior to the discovery of the present new species from Death Valley, *Tetracoccus* remained, therefore, a monotypic genus containing only the rare and local species, *T. dioicus,* discovered half a century ago.

In *Tetracoccus dioicus* the leaves are linear and entire, with a maximum length of about 30 mm and a maximum width of about 5 mm, and with no lateral veins; the clusters of male flowers are in the axils of leaves on the new growth, a final cluster often terminating the twig; and the young twigs and leaves are devoid of pubescence.

The lack of fully mature fruit and seeds of the new species makes impossible a wholly satisfactory comparison of these parts. In a boiled capsule of *T. ilicifolius* collected on May 30 the strophiole on an immature seed is 2 mm long and 1 mm thick at the upper end (the end of the strophiole away from the hilum), the body of the immature seed on which this strophiole is borne being 4.5 mm long when wet and soft. In one, and presumably all, of the eight fruits collected on August 2, 1936 (Gilman 2235), and about two months nearer maturity than those first collected, two seeds are maturing in each of the capsule cells. The seeds are buff-colored at this stage, about 2.5 mm wide, 1.5 mm thick, and 4.5 to 4.7 mm long, the strophiole amber-colored and translucent, and in its dried condition 1.5 mm. long. In *Tetracoccus dioicus* a single seed, usually, matures in each cell. Its width and thickness are both about 2.5 to 2.8 mm, its length about 4.7 to nearly 6 mm, and its color at full maturity dark brown. The strophiole is about 1 mm long and it extends not quite to the apex of the seed. Although the capsules of *ilicifolius* collected August 2 are not sufficiently mature to have split open naturally, their bony inner wall is half a millimeter thick. On being opened

[2] Proc. Amer. Acad. **20**: 372. 1885.

[3] Op cit. 373.

[4] On February 5, 1885, according to William Trelease and Asa Gray, *The botanical works of the late George Engelmann,* page 449, 1887.

[5] West Amer. Scientist **1**: 13. 1885.

[6] Zoe **5**: 229. 1906.

[7] Contr. Gray Herb. n. ser. **68**: 88. 1923.

the capsules show a tendency to split down the middle of each cell, each bony half-cell tending also to separate from the corresponding part of the neighboring cell, just as in *Tetracoccus dioicus*.

All botanists who have described the seeds of *Tetracoccus dioicus* state that only a single seed matures from the two ovules in each cell. However, excellent specimens of that species collected July 30, 1936, in San Diego County, California, by Frank F. Gander, Curator of Botany in the Natural History Museum, San Diego, have occasional cells in which both the ovules have developed into seeds, each seed containing an endosperm and a full-sized embryo. When two seeds ripen in a single cell they are much thinner than the single seeds of this species described in the preceding paragraph.

When examined in Washington on November 19, 1936, nearly four months after it was taken from the bush and pressed for the herbarium, Mr. Gander's specimen bore several capsules that were mature and still intact. During the following night, in the dry atmosphere of a steam-heated building every one of these mature capsules exploded. In exploding, the walls of the four cells broke away from the central axis in eight pieces, and the seeds were thrown clear, some of them to a distance of several feet. The explosion was caused by the release of stresses in the bony inner wall of the capsule.

In *dioicus* the sepals of the female flowers and their peduncles are glabrous, as well as the branches of the inflorescence in the male plants. Near the axils of the bracts of the male flowers are traces of the same sort of pubescence that occurs in *ilicifolius*.

In his original publication on *Tetracoccus* Watson described the female flowers in *T. dioicus* as having 6 or 7 sepals. Parry gave the number as 7 to 9. In specimens of *dioicus* from Santo Tomás, in the National Herbarium, the sepals in the female flowers are sometimes as many as 10, 11, or even 12. In *T. ilicifolius*, in all the immature fruits in which the sepals are in condition to be counted with accuracy, their number is 8. Future examination of new material, however, may show that the number varies.

The ovary of the female flowers in *dioicus* is tomentose with a red tomentum, but the mature capsule is nearly glabrous. The lack of female flowers in our specimens of *ilicifolius* and access to only dried remnants of male flowers still clinging among the leaves make impossible a thorough comparison of the flowers of the two species.

The existence of this new species in a single restricted locality in one of the severest of our deserts, the fewness of the individual plants, and the scarcity of fruit are evidence that the plant is in process of extinction through a still further increase in the aridity of Death Valley, a suggestion supported by similar evidence regarding other plants, such as *Gilmania luteola*.[8]

A 4-celled ovary is rare in the family Euphorbiaceae, but in the sub-family Phyllanthoideae (typified by the genus *Phyllanthus*) genera with 4-celled fruits occur in parts of the world far separated from the continent of North

[8] This Journal **26**: 209–13. 1936.

America, such as *Heywoodia* in South Africa.[9] Other characteristics of these genera, however, do not suggest any immediate genetic relationship with *Tetracoccus*, and we may be content to regard this genus as having developed its 4-celled capsule, among its 3-celled relatives, in our own North American arid region.

BOTANY.—*Three new grasses from Indo-China.*[1] JASON R. SWALLEN, Bureau of Plant Industry.

In a small collection of grasses recently received from Professor A. Petelot, of the Ecole de Médicine, Hanoi, Tonkin, collected by him in Indo-China, the following new species were found: *Centotheca uniflora*, *Isachne ascendens*, and *Isachne dioica*.

Centotheca uniflora Swallen, sp. nov.

Perennis; culmi erecti vel geniculati, 80–85 cm longi, glabri; vaginae internodiis breviores, glabrae, marginibus ciliatis; ligula truncata, 0.5 mm longa; laminae planae, 14–21 cm longae, 13–17 mm latae, reticulatae,

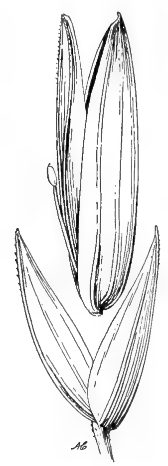

Fig. 1.—*Centotheca uniflora.* Glumes and floret (palea and rachilla joint with rudimentary floret displayed) ×10. Type.

glabrae, marginibus scabris; panicula 40–45 cm longa, ramis adscendentibus ad 19 cm longis basi nudis; pedicellii 3–12 mm longi, divergentes; spiculae 3.5–4 mm longae, uniflorae; rachilla producta; glumae subaequales lemma duplo breviores, 3–5 nerves, acutae vel mucronatae, glabrae; lemma 3.5 mm longum, 5–7 nerve, mucronatum, glabrum; palea lemma aequalis.

Perennial; culms erect to geniculate-spreading, 80–85 cm long, glabrous; sheaths a little shorter than the internodes, glabrous, somewhat ciliate toward the summit; ligule 0.5 mm long, membranaceous, truncate; blades

[9] Pax and Hoffmann, Natürlichen Pflanzenfamilien, 2. aufl. **19c**: 74. 1931.

[1] Received September 13, 1936.

lanceolate acuminate, conspicuously cross veined, 14–21 cm long, 13–17 mm wide, glabrous on both surfaces, the margins scaberulous; panicle 40–45 cm long, somewhat flexuous or drooping, the subcapillary ascending branches rather distant, naked below, very compound, the lower ones as much as 19

Fig. 2.—A. *Isachne dioica.* Plant ×1; spikelet and upper floret ×10. Type. B. *Isachne ascendens.* Spikelet and pair of florets ×10. Type.

cm long; pedicels spreading, 3–12 mm long; spikelets 3.5–4 mm long, only one floret developed; glumes subequal, acute or mucronate, 3–5 nerved, about half as long as the spikelet; lemma 3.5 mm long, strongly 5–7 nerved, subobtuse, minutely lobed, mucronate, glabrous; palea narrow, 2-keeled, equaling or slightly exceeding the lemma; rachilla joint $\frac{1}{3}$ to $\frac{1}{2}$ as long as the palea, sometimes bearing a very small rudimentary floret.

Type in the U. S. National Herbarium no. 1645234, collected in "petite massif de Ang Son, village de Van Huan, Province de Quang Binh," Annam, Indo-China, February 26, 1936, by A. Petelot (no. 5635).

While this species is anomalous in having but a single floret, the character of the plants as a whole agrees with that of *Centotheca*. Two good specimens were available for study, in both of which there was no exception to the one-flowered spikelets. This is sufficient to indicate that the specimens are not abnormal.

Isachne ascendens Swallen, sp. nov.

Annua?; culmi geniculati, adscendentes, ad 30 cm alti, glabri; vaginae internodiis breviores, sparse hispidae, marginibus ciliatis; ligula ciliata, 1 mm longa; laminae planae, firmae, acutae, 3–8 cm longae, 4–8 mm latae, dense pubescentes; panicula 12–14 cm longa, ad 6 cm lata, ramis adscendentibus, basi nudis, inferioribus 6–8 cm longis; spiculae 1.5 mm longae, pedicellibus 2.5–4 mm longis appressis; glumae 1.3 mm longae, obtusae, sparse hispidae vel subglabrae; flosculi simulantes, elliptici, 1.3 mm longi, pubescentes.

Annual?; culms geniculate-ascending, about 30 cm tall, glabrous; sheaths shorter than the internodes, sparsely hispid, the margins ciliate; ligule ciliate, 1 mm long; blades flat, firm, acute, 3–8 cm long, 4–8 mm wide (mostly more than 5 cm long and 5 mm wide), appressed pubescent, densely so beneath; panicle 12–14 cm long, about 6 cm wide, the compound branches ascending, naked at the base, the lower ones 6–8 cm long; spikelets 1.5 mm long, the pedicels appressed, 2.5–4 mm long; florets similar, elliptic, 1.3 mm long, pubescent.

Type in the U. S. National Herbarium no. 1645231, collected in "sentiers dans les savanes herbeuses, Massif du Sang ..... Van Nus, 1600 m, Chapa, Tonkin," Indo-China, July, 1936, by A. Petelot (no. 5617).

This species of *Isachne* is closely related to *I. beneckii* Hack., but differs in having a much stiffer tufted habit, unbranched culms, shorter and broader blades, and appressed spikelets.

Isachne dioica Swallen, sp. nov.

Annua; culmi debiles, decumbentes, ramosi, 10–20 cm longi; vaginae internodiis multo breviores, pilosae vel subglabrae; ligula pilosa 0.5 mm longa; laminae planae, ovatae, 7–16 mm longae; 3–7 mm latae, pilosae, marginibus scabris; paniculae 2–4 cm longae, ramis divergentibus ad 10 mm longis; spiculae 1.8–2 mm longae; glumae 1.3–1.5 mm longae, sparse hispidae, 5-nerves, divergentes; flosculus primus masculus, lemmate membranaceo, 1.8 mm longo, glabro; flosculus secundus femineus, induratus, pubescens, 0.8 longus, plano-convexus.

Annual; culms weak, decumbent-spreading, usually branching, 10–20 cm long; sheaths much shorter than the internodes, pilose or subglabrous; ligule pilose, 0.5 mm long; blades flat, thin, ovate, 7–16 mm long, 3–7 mm wide, pilose, the margins scabrous; panicle 2–4 cm long, the branches ascending to spreading or even reflexed at maturity, as much as 10 mm long, naked below; spikelets 1.8–2 mm long; glumes equal, 1.3–1.5 mm long, divergent, 5-nerved, sparsely hispid; first floret staminate, the lemma membranaceous, 1.8 mm long, glabrous, the stamens 1.5 mm long; second floret pistillate, indurate, plano-convex, 0.8 mm long, brownish, minutely appressed-pubescent with white hairs, borne on a slender white rachilla joint.

Type in the U. S. National Herbarium no. 1645232, collected in "Rizière argilo-calcaire abandonnée, Village de Van Huan, Province de Quang Binh, Annam" Indo-China, February 26, 1936, by A. Petelot (no. 5634).

The large membranaceous staminate floret and the small indurate pistillate floret borne on an exceptionally long rachilla joint are characteristic. At maturity the glumes and the pistillate floret fall off leaving the staminate floret and the rachilla joint attached to the pedicel.

ZOOLOGY.—*Bryozoa collected in the American Arctic by Captain R. A. Bartlett.*[1] RAYMOND C. OSBURN, Ohio State University. (Communicated by WALDO L. SCHMITT.)

The collections made by Captain Robert A. Bartlett over many years in the Arctic have added much to our knowledge of the occurrence and distribution of the various forms of life. Recently the United States National Museum sent to the writer for determination the Bryozoa from seventeen collecting stations ranging from Hudson and Davis Straits to northwest Greenland. Seven of these were taken by the Norcross-Bartlett Expedition in 1933. The others are scattered collections dated 1926, 1927, 1932 and 1935.

While the Bryozoa are thus apparently incidental collections, they serve to indicate the richness of the fauna in this group in these Arctic waters. A number of the species have not been listed hitherto in the waters west of Greenland and the range of other species is extended.

Perhaps the most characteristic species is the well known *Microporina borealis* (Busk) which occurred at eleven of the stations, in bushy masses reaching a height of four to as much as six inches. It appears to afford a favorite lodging place for many other bryozoan species. In a half pint jar of *M. borealis* taken near Dalrymple Rock, Wolstenholm Sound, N. Greenland, there were found the following 23 species encrusting or attached to the stems:

Gemellaria loricata (L), *Scrupocellaria scabra* (v. Ben.), *Dendrobeania murrayana* var. *fruticosa* (Packard), *Electra crustulenta* var. *arctica* Borg, *Callopora craticula* (Alder), *C. lineata* (L.), *Tegella unicornis* (Fleming), *T. armifera* (Hincks), *Cauloramphus cymbaeformis* (Hincks), *Hippothoa hyalina* (L), *Harmeria scutulata* (Busk), *Myriozoella plana* (Dawson), *Hippodiplosia reticulopunctata* (Hincks), *H. porifera* (Smitt), *Rhamphostomella ovata* (Smitt), *R. costata* Lorenz, *R. plicata* (Smitt), *R. scabra* (Fabr.), *R. spinigera* Lorenz, *Smittina arctica* (Norman), *Costazia ventricosa* (Lorenz), *Lichenopora verrucaria* (Fabr.), and *Crisia* sp.

The localities are listed below and these will be referred to under the various species by the numbers indicated in the list.

[1] Received October 9, 1936.

1. Off Dalrymple Rock, Wolstenholm Sound, N. Greenland, July 22, 1926.
2. Murchison Sound, N. Greenland, August 20, 1926.
3. 66° 30′ N., 80° W., August 10, 1927.
4. Five miles S. of Cape Chalon, N. Greenland, July 27, 1932.
5. Three miles S. of Salisbury I., Hudson Str., 20 Fath., July 25, 1933.
6. W. end of White I., Frozen Str., Fox Channel, August 10, 1933.
7. Hurd Channel, between Bushman I. and Melville Pen., Fox Channel, August 17, 1933.
8. Cove No. 40, N. shore of Lyon Inlet, Melville Pen., Fox Channel, August 24, 1933.
9. Cove No. 50, N. shore of Lyon Inlet, Melville Pen., Fox Channel, August 25, 1933.
10. Entrance to Fury and Hecla Str., 20–30 Fath., Sept. 3, 1933.
11. N. E. entrance to Fury and Hecla Str., Sept. 5, 1933.
12. Hakluyt I., Whale Sound, 77° 26′ N., 72° 30′ W., 68–120 feet, July 30, 1935.
13. E. end of Cobourg I., Baffin Bay, 75° 40′ N., 78° 40′ W., 140–210 feet, August 3, 1935.
14. The same, but 75° 40′ N., 78° 50′ W., 140–210 feet, August 3, 1935.
15. The same, but 75° 40′ N., 78° 53′ W., August 3, 1935.
16. The same, but 75° 40′ N., 78° 55′ W., 150–280 feet, August 3, 1935.
17. S. end of Cobourg I., 75° 40′ N., 78° 58′ W., 40–80 feet, August 4, 1935.

Altogether 60 species occur in these collections, six of which have not previously been reported for this part of the American Arctic. These species are *Crisia cribraria* Stimpson, *Diaperoecia harmeri* Osburn, *Plagioecia* (*Mesenteripora*) *grimaldii* (Jullien and Calvet), *Flustrella corniculata* (Smitt), *Electra crustulenta* var. *arctica* Borg, and *Bugula simpliciformis* Osburn. (For the waters about Greenland and westward see the compiled lists by Osburn, 1919, and 1923, and Nordgaard,—Second Fram Exped., 1906.)

Crisia cribraria Stimpson has been noted only on the American coast from Cape Cod to Labrador; *Diaperoecia harmeri* Osburn from Maine to Nova Scotia, *Flustrella corniculata* (Smitt) is an Arctic species reported from Norway, Spitzbergen and Alaska (the present record fills a large gap in the known distribution). *Bugula simpliciformis* Osburn has been recorded only from Hudson Bay. *Plagioecia grimaldii* (Jullien and Calvet) was described from the Grand Banks of Newfoundland.

Thirty-eight species of the present list were recorded by Nordgaard (1906) in the waters west of Greenland.

In the following list of species taken by Capt. Bartlett, localities are given, for the sake of brevity, in station numbers which may be referred to above.

Endoprocta.—*Barentsia* sp. 15. One young specimen, too small for identification.

CYCLOSTOMATA.—*Crisia cribraria* Stimpson. 6, 9. Well developed colonies, with ovicells. Hitherto this species has been known only from Cape Cod northward to Nova Scotia.

Crisia sp. 9. Probably *C. denticulata* (Lamarck), but without ovicells and too young for positive identification.

Diaperoecia (*Entalophora*) *harmeri* Osburn. 6, 9. This species was described and listed by Osburn (1933, p. 301) from Georges Bank to Nova Scotia. It is not surprising to find it in Arctic waters where it may have been noted previously as a species of Entalophora.

Diplosolen (*Diastopora*) *obelium* (Johnston). 9. Widely distributed in temperate and colder waters.

Oncousoecia (*Diastopora*) *diastoporides* (Norman). 13. Widely distributed in northern waters.

Plagioecia (*Mesenteripora*) *grimaldii* (Jullien and Calvet). 13, 14, 15. In each case a single, stipitate, folded colony with ovicells. The ovicells resemble those of *Tubulipora patina,* but are less transverse than those illustrated. Many of the zooecial tubes are closed, with the closing membrane smooth or perforated or frequently with the small central tubules common in *sarniensis* and some other cyclostomes. The species may prove to be *patina,* but the differences seem to be sufficient to separate it.

Tubulipora flabellaris (Fabricius). 12. Widely distributed in temperate and northern waters.

Lichenopora verrucaria (Fabricius). 4, 6, 9, 11, 12, 13, 14, 17.

CTENOSTOMATA.—*Alcyonidium disciforme* Smitt. 8. The largest representative of this species previously reported was but 17 mm in diameter. Two of three specimens picked up between tides along the north shore of the cove (8) measured respectively 28 and 34 mm in diameter. These disclike colonial forms were centrally perforate, a condition which seems to have been noticed only once before in scientific literature (Levinsen, Bryozoer fra Kara Havet, 1886, pl. 27, fig. 13). The openings may indicate that this bryozoan at times grows around a stalk of some sort. The only other specimens that I have seen of this species were several of much smaller size, 12 mm in diameter, and without the central holes. They were found attached to stones and algae in Wakeham Bay, Ungava, at very low tide, October, 1927.

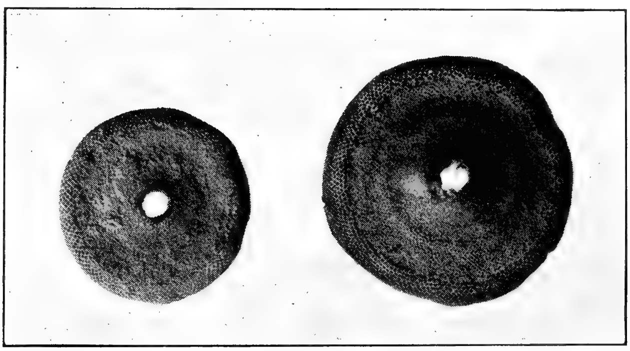

Fig. 1.—*Alcyonidium disciforme,* nat. size. Two specimens of the rarely found perforate form. The largest previously known specimen was about two-thirds of the size of the smaller one figured here.

Bowerbankia gracilis Leidy. 2. *B. caudata* (Hincks) and *Farella arctica* Busk, both recorded for Artic waters, are probably synonymous.

Flustrella corniculata (Smitt). 8, 9. Previously known from Norway and Spitzbergen, and from Alaska (*Alcyonidium cervicornis* Robertson). The present record, which is the first from the American Archipelago, fills a large gap in the circumpolar distribution of the species.

Cheilostomata.—*Gemellaria loricata* (Linnaeus). 1, 4, 9.

Membranipora serullata (Busk). 9, 10, 13, 14. Rather abundant at these stations and occurring in both the encrusting, unilaminar, and the flustrine condition as narrow irregular fronds.

Electra crustulenta (Pallas) var. *arctica* Borg. 1, 12, on shell and pebbles. Dr. Folke Borg (1931) has made a careful analysis of several much confused species of the old genus *Membranipora,—membranacea, reticulum, lacroixii, crustulenta, mülleri, monostachys* and *catenularia*. It is very difficult to state the distribution of these species, due to misidentification by even the best workers of the past. It is certain however, that the present species is Borg's var. *arctica,* since it has the well calcified operculum.

Callopora craticula (Alder). 1, 6.

Callopora lineata (Linnaeus). 1, 6, 12.

Callopora spitzbergensis (Bidenkap). 4, 12.

Callopora spathulifera (Smitt). 6, 9, 10.

Tegella arctica (d'Orbigny). 12. Several colonies, one more than an inch across, on a pebble.

Tegella unicornis (Fleming). 1, 4, 6, 12.

Tegella unicornis var. *armifera* (Hincks). 1, 2, 12.

Cauloramphus cymbaeformis (Hincks). 1, 2.

Scrupocellaria scabra (van Beneden). 1, 12, 14, 17.

Tricellaria (*Menipea*) *ternata* (Solander). 3, 8, 9, 13. Mostly of the var. *gracilis* (Smitt).

Tricellaria (*Bugulopsis*) *peachi* (Busk). 4, 10.

Bugula simpliciformis Osburn. 10, 14. There is some doubt about the specimen from Sta. 10 as it lacks both avicularia and ovicells, but the other characters agree well with the type. This species was described (Osburn, 1932, p. 369) from Hudson Bay. All the colonies seen thus far have been small, less than an inch in height, with simple zooecial and zoarial characters.

Dendrobeania murrayana var. *fruticosa* (Packard). 1, 4, 6.

Microporina borealis (Busk). 1, 2, 5, 7, 9, 10, 12, 13, 14, 17. The most abundant and generally distributed species in the collection and harboring most of the other species noted.

Cribrilina annulata (Fabricius). 4, 6, 12.

Hippothoa hyalina (Linnaeus). 1, 2, 4, 6, 9, 10, 12. Encrusting algae, bryozoa and pebbles.

Harmeria scutulata (Busk). 1, 6, 12.

Cylindroporella tubulosa (Norman). 12. Encrusting pebbles.

Posterula sarsi (Smitt). 10, 14. Fine examples of the erect, branching form.

Stomachetosella (*Lepralia*) *producta* (Packard). 12. One small colony on a pebble. As far as I am aware this species has been recorded only once before in Arctic waters (Kluge, 1907, West Greenland).

Hippodiplosia (*Smittina*) *reticulatopunctata* (Hincks). 1.

Hippodiplosia (*Smittina*) *porifera* (Smitt). 1.

Peristomella jacksoni (Waters). 4.

Microporella ciliata var. *arctica* (Norman). 12.

Mucronella connectens (Ridley) = *Escharella indivisa* Levinsen. 6, 10, 12, 14. On algae and pebbles. In describing this species Levinsen (1916, p. 450) appears to have overlooked Ridley's description of *Mucronella ventricosa* var. *connectens* (1881, p. 451). Ridley misinterpreted the large undivided pore chambers, upon which Levinsen especially based his species, but his figures (Pl. XXI, figs. 6, a and b) show this character almost exactly as figured by Levinsen (Pl. XX, figs. 1 and 2). Ridley states that the broad oral denticle has lateral points, while Levinsen indicates it as straight, but my material shows some variation. The other characters are in agreement. I am therefore returning to the use of Ridley's name.

Smittina arctica (Norman). 13.

Rhamphostomella ovata (Smitt). 1, 6, 10.

Rhamphostomella plicata (Smitt). 1.

Rhamphostomella bilaminata (Hincks). 13.

Rhamphostomella scabra (Fabricius). 1.

Rhamphostomella costata Lorenz. 1, 2, 13.

Rhamphostomella spinigera Lorenz. 1.

The presence of six out of the seven arctic forms of *Rhamphostomella* (*R. radiatula* Hincks is the only one lacking) might appear unusual but for the preference which the species of this genus have for attachment to stems such as those of *Microporina borealis*.

Porella acutirostris Smitt. 10, 12, on algae and pebbles.

Porella compressa (Sowerby). 10. Well-developed, branched colonies.

Porella princeps Norman. 14.

Porella struma var. *glaciata* (Waters). 4. Spreading, foliaceous colonies, sometimes of more than one layer.

Cystisella (*Porella*) *saccata* (Busk). 4, 13.

Cheilopora sincera (Smitt). 13, 14. The *Mucronella praelucida* of Hincks must undoubtedly be considered a synonym of *sincera* Smitt, at least as far as records from eastern North America are concerned. The zooecia in specimens from the Gulf of St. Lawrence, Labrador and Hudson Bay are considerably smaller, but in the present material I find, even within the same colony, zooecia which range from the small St. Lawrence type to even larger than the measurements given by Smitt for Spitzbergen and Finmarken specimens. There appear to be no other distinctive characters.

Retepora elongata Smitt. 10, 13, 14, 15.

Lepraliella contigua (Smitt). 13.

Myriozoum subgracile d'Orbigny. 13, 14, 15, 16.

Myriozoella plana (Dawson) = *crustacea* Smitt. 1, 2, 6, 10, 12, 14, 17. Very common, encrusting algae, the stems of *Microporina* and pebbles.

Costazia (*Cellepora*) *ventricosa* (Lorenz). 1, 7, 10, 14.

Costazia (*Cellepora*) *surcularis* (Packard). 10, 13, 14.

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ENTOMOLOGY.—*A note on the occurrence of a pupal abnormality in the flour beetle* Tribolium confusum *Duval.*[1] THOMAS PARK, The Johns Hopkins University. (Communicated by RAYMOND PEARL.)

A rather curious pupal abnormality noted among stock cultures of the flour beetle *Tribolium confusum* seems worthy of brief mention. Two pupae were observed which obviously differed from the normal types in having their thorax and abdomen spirally rotated to the right with a corresponding distortion of the longitudinal axis. These relationships can be seen in Fig. 1 where photo-micrographs of normal and abnormal pupae in dorsal and ventral views are presented. In each illustration black lines have been ruled to correspond with the longitudinal axes. For the normal pupa a single, straight line accurately bisects the individual into right and left sides for head, thorax and abdominal regions. In the abnormal pupa it is necessary to draw four distinct lines to describe the axis from the dorsal view and three from the ventral view. Since nothing is known as to the larval history of these two individuals it is impossible to state if the abnormality was acquired early or late in metamorphosis. Likewise, it is impossible to conclude whether the abnormality is merely some developmental accident or whether a more fundamental basis is involved.

Interest was first attracted to these pupae since, in spite of their structure, they appeared very much alive and gave every indication of developing into imaginal forms. All young *Tribolium* pupae when lightly touched on the mid-ventral surface exhibit a marked flexing movement of the abdomen and it is frequently possible to distinguish between living and dead forms in this manner. This reflex was well developed for the two atypic pupae and suggested that, even though they possessed such an unusual external morphology, certain neuromuscular connections had been established at the time which permitted the described behavior to take place.

[1] Received September 17, 1936.

Of the two twisted pupae, one was a male and the other a female. The latter failed to emerge as an adult *Tribolium* while the former not only emerged but lived about nine weeks. This beetle showed few of the abnormalities characteristic of the pupa: the head and thorax were outwardly entirely normal and only the posterior part of the abdomen exhibited any deviation from type. This deviation con-

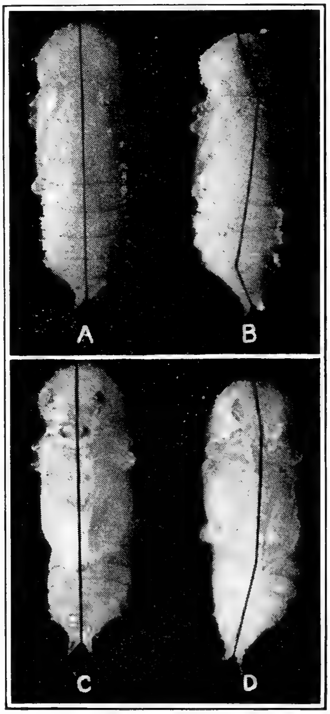

Fig. 1.—Photomicrographs of: A, Dorsal view of normal pupa; B, Dorsal view of abnormal pupa; C, Ventral view of normal pupa; D, Ventral view of abnormal pupa. (Enlarged about 10 times.)

sisted of a slight rightward turning of the terminal abdominal segments. The beetle, however, did not prove fertile for, although it was placed with several normal, virgin females, no viable eggs resulted. Whether this was due simply to the inability of the form to copulate, or, whether some more deeply seated mechanism was involved, cannot be said.

The principal purpose of this note is to place on record a new type of abnormality for *Tribolium*. The author is aware of three other such records. Two of these relate to metathetely or the appearance of wing rudiments in larvae of *Tribolium confusum*. The first report,

that of Chapman (1926), showed that larvae of the flour beetle occasionally develop wing pads when subjected to a "gas" sometimes produced by adult *Tribolium* when present in very dense and disturbed populations. The second report (Nagel, 1934) described the appearance of metathetelous, last instar larvae due to low temperature. The third record (Park) reports the occurrence of a Mendelian recessive gene which causes certain central facets in the eyes of *Tribolium castaneum* Herbst to lack pigment.

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An * denotes the abstract of a paper before the Academy or an affiliated society.

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